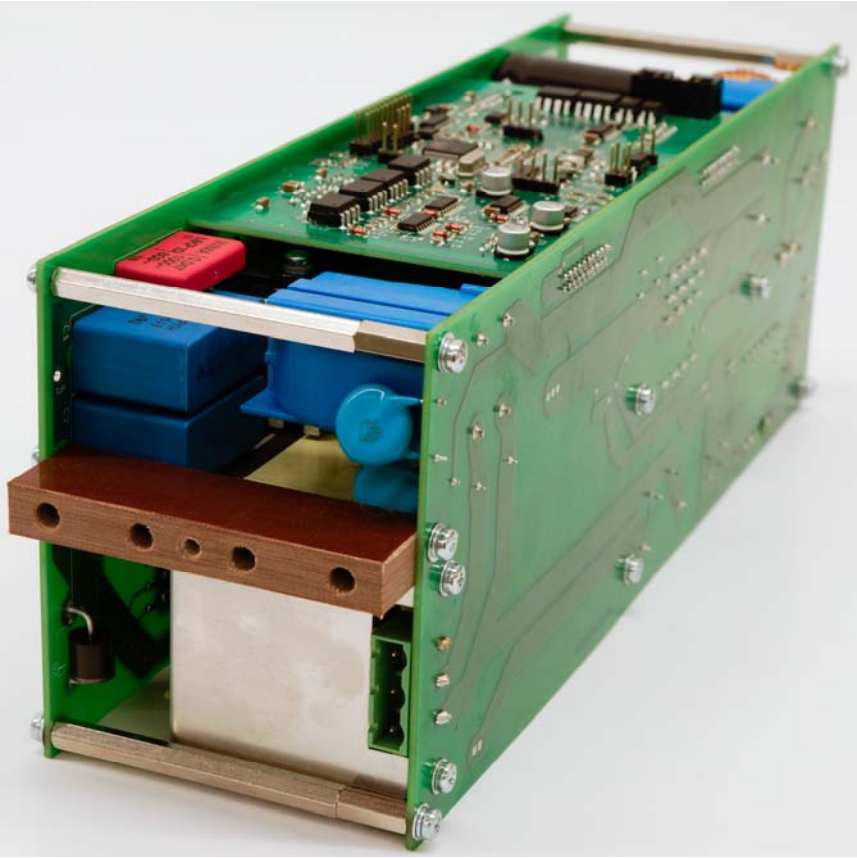
FLEXIVA

User Manual



PM3K350

Bidirectional 3.5 kW DC/DC Converter Module

Article No.: BNH-PM3K350-1x
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Preface

The present Technical Documentation is to inform of the correct operation of the DC/DC converter modules PM3K350. The modules serve to convert direct voltages in a bidirectional way.

The operating manual is to be preserved.

It is prohibited to copy or duplicate texts, plans, and tables or to make them accessible to any third parties without our express consent.

We draw your attention to the fact that the Technical Documentation shall not be part of an existing earlier agreement or promise or part of a legal relationship.

All and any obligations result from the purchase contract that also solely contains the warranty determination. The contractual provisions shall not be affected by the Technical Documentation.

The documentations of the suppliers used shall apply along with the present documentation of the manufacturer.

In addition to the operating manual, all universally valid legal and other obligatory regulations concerning the prevention of accidents and the environmental protection are to be complied with and to be instructed.

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1 Introduction

In order to guarantee the safety of the operator and to avoid possible damages at the module, you have to ensure by all means that the present user's manual has been read completely before starting to use the module and/or the plant connected with it.

The present user's manual is to help you to get to know the DC/AC module better and to enable you to use it according to the intended working possibilities.

Prior to the commissioning, the operating staff has to familiarize itself with all sub-units and their functions. Particular attention is to be paid to the paragraph safety.

The present user's manual contains important information on the correct and economical application of the DC/AC module. The compliance with these instructions contributes to the fact that dangers are avoided, costs owing to repairs and breakdown times are reduced, and the service life of the module is prolonged.

A symbol is provided at the text margin in the chapters if required that refers to the function of the respective text section and is of importance with regard to the operation or the maintenance and/or indicates important descriptions or notes:

Danger

All sections in the manual containing information on possible dangers are marked with the marginal symbol.
The non-observance can lead to serious injuries! The instructions are to be strictly complied with.

Attention

All sections with this symbol provide instructions how to avoid damages at the unit.

Advice

Sections with this symbol give important details for an efficient work.

The work steps that are described in logical order at the side of this symbol inform the operator of the most ergonomic proceeding of the operation.

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2 Identification

2.1 Product Trademark and Type Designation

ZEMIS® PM3K350

2.2 Product Version / Version of Software / Editing State

Product Version: PM3K350-1x

Firmware: 2.06

State: 2015

3 Product Description

3.1 General Information / Utilization as Directed

The DC/DC converter module serves to couple various sources, acceptors, and storing elements of electric energy with each other by means of a DC link that have absolutely different ranges of operating voltages between 0V and 350V. If offers a high efficiency, a flexible control as well as a digital interface. Because of the DC link voltage of 375V, a simple coupling of a 230V AC system is possible.

Attention

The PM3K350 module does not offer any galvanic isolation of DC link and output! In case of the interconnection with other modules without galvanic isolation, this can lead to the damaging of the PM3K350 module.

Terms and abbreviations

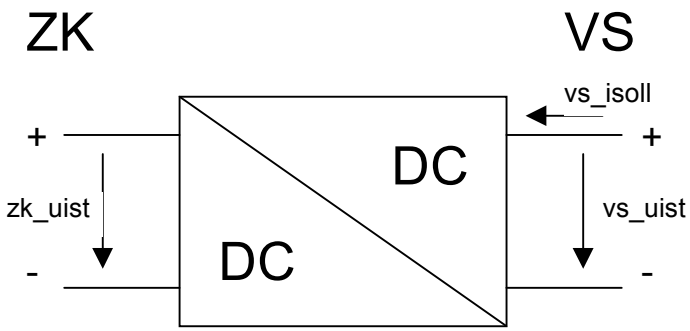


Fig. 1: Principle

ZK: Prefix: _zk	DC link – this is the designation for the side of the module by means of which the coupling with other DC/DC modules or the link of any other 380V DC component (e.g. inverter) can be carried out.
VS: Prefix: _vs	Variable voltage – this is the designation for the side of the module to which the components are connected. The designation output is also used but it is not quite correct because of the bidirectional mode of functioning.
Step-up operation:	Designates the power flow from the variable voltage side to the DC link side. The sign of the current (vs_isoll) is positive.
Step-down operation:	Designates the power flow from the DC link side to the variable voltage side. The sign of the current (vs_isoll) is negative.

3.2 Technical Information and Data

General characteristics

Bi-directional power flow:	yes
Parallel connection:	yes
Galvanic isolation: (ZK vs. VS)	no

Performance data

Rated power:	3.5 kW
Current range:	-10…0…10A
Variable voltage range:	0...380V DC (variable voltage < DC link voltage)
DC link voltage:	100…395V DC
Control interface:	USART (CMOS 5V); galvanic isolated
Auxiliary power supply:	12…30V DC, 10W; galvanic isolated
Own consumption:	standby: max. 5W during operation: max. 10W
Cooling:	forced air cooling (temperature-controlled fan)
Efficiency:	> 90%
Accuracy:	better than ± 3 % of full scale

Ambient conditions

Ambient temperature range:	-20...50°C (during operation)
Degree of protection:	IP 00
Maximum humidity:	up to 90% (non-condensing)
Pollutants:	The environment must not contain larger quantities of dust, in particular no metal or graphite dust.

Housing

Design:	open frame
Dimensions:	270 mm x 85 mm x 105 mm
Weight:	approx. 2.2 kg

Scope of delivery

- DC/DC converter module PM3K350 (pre-parameterized)
- Data disk (CD)
- Software for visualization and parameterization (on CD)
- User manual (on CD)

Optional

- Device system for max. 4 modules (variants on request)
- Pre-parameterization according to the planned application

3.3 Power Connectors

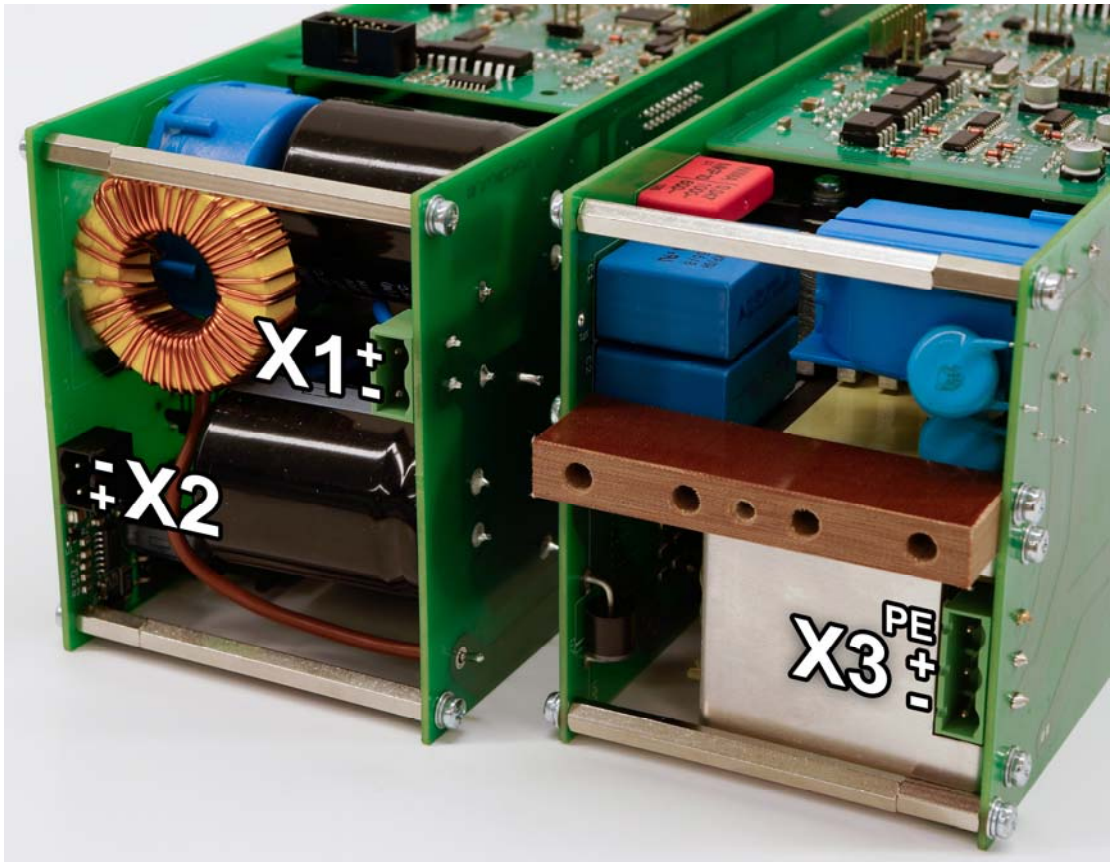


Fig. 2: Power connectors

X1: DC link connector (ZK side)

- Plug with clamp max. 2.5mm²

X2: Power supply connector

- Plug with clamp max. 1.5mm²
- 12…30V DC

X3: Variable voltage connector (VS side)

- Plug with clamp max. 2.5mm²
- +pole, -pole, PE

3.4 Signal Connectors

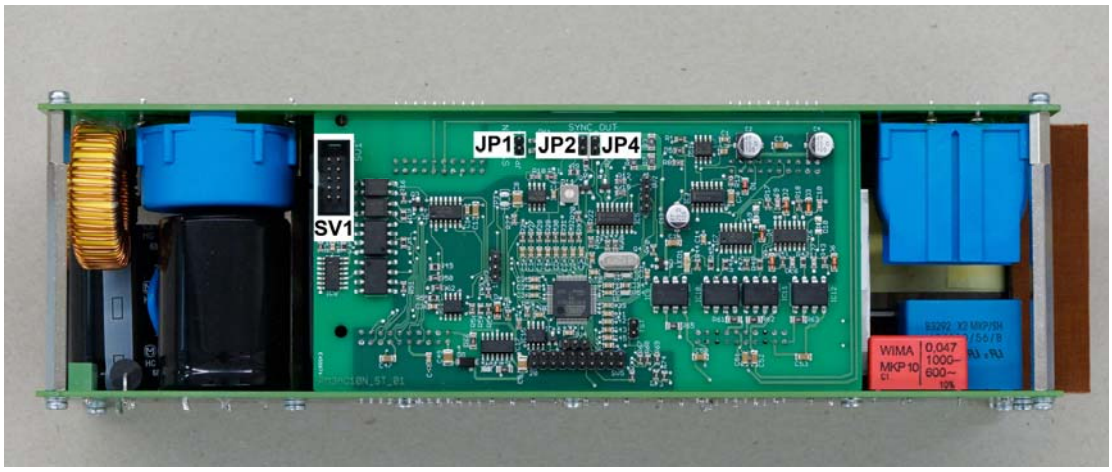


Fig. 3: Signal connectors

SV1: Communication interface

The communication with the module is executed by means of an optically isolated serial interface: To trigger the optocouplers, a supply voltage of 5V (approx. 30mA) is to be provided. To permit to address several modules in a simple way, the signal RXD and TXD can be switched-in by means of the SELECT signal. When SELECT is low, TXD becomes a high-resistance value and RXD does not receive any signals. When several modules are used, the RXD and TXD lines can be connected in parallel this way and the currently addressed module can be selected by means of SELECT. All signals at this interface are on 5V CMOS level that means for the connection with a PC, a level converter is required such as, for example, represented in the appendix.

Data rate: 115,200bps,

Format: 8bit+1 stop bit

The signals OC_OK and OC_EN are provided for an additional safety feature: OC_OK gets low, when the DC link voltage has exceeded the upper limit value. Consequently, a module can inform all the others when this case has occurred by AND-combining all OC - OK signals and supplying them to OC - EN. This way, it is possible to prevent major damages when the voltage-measuring amplifier of the DC link of a module breaks down.

pin	abbreviation	explanation
1	GND	ground
2	VCC	+5 V
3	OC_OK	H: no overvoltage of the DC link
4	NC	not used
5	NC	not used
6	SELECT	H: serial interface activated L: serial interface deactivated
7	OC_EN	H: module enabled
8	RXD	input of data
9	NC	not used
10	TXD	output of data

Tab. 1: Pin assignment SV3

SV2, SV3, SV4, SV5, TST: Service interfaces

The service interfaces are not needed for normal operation. These should not be used.

JP1, JP2, JP4: Not used

3.5 Basic Structure and Function of the DC/DC Module

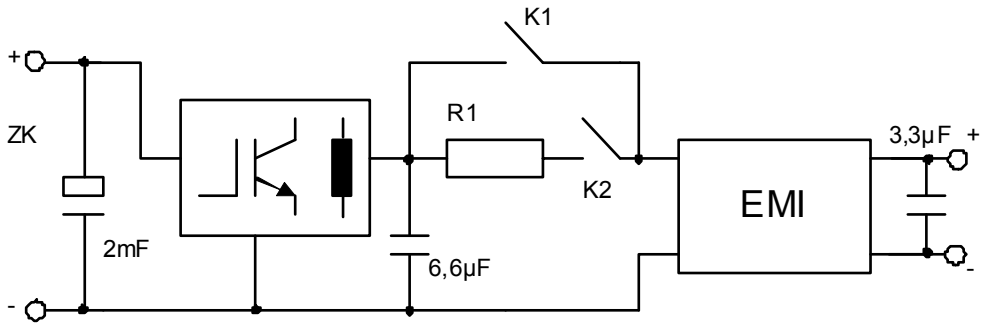


Fig. 4: Basic structure and function

3.6 Safety Information

The DC/DC converter module was developed according to recognized rules of technology and submitted to a safety test before the delivery.

In case of wrong operations or unauthorized use, there are still dangers for persons and the DC/DC converter modules.

All persons who erect, operate, or maintain the system must:

1. read and exactly follow the present operating manual,
2. be trained and instructed for their job.

Test voltage between DC link side and communication interface 6kVp

3.6.1 Safety Measures for the Installation

In order to guarantee a troublefree operation and to maintain the service life of the electronic components, any accumulation of heat, especially at the fronts of the module is to be avoided. The place of installation is to be selected so that the module is sufficiently ventilated during the operation.

Attention

The heat sinks are connected with potentials i.e. it is prohibited to touch them!

3.6.2 Remaining Dangers and Risks

The described product is in keeping with the latest technological development and meets the recognized safety provisions. Nevertheless, dangers and risks may arise.

The remaining dangers and risks occurring in connection with the operation of the system result from:

- the utilization of electric / electronic components (sources, acceptors, memories) of third-party suppliers,
- the electricity itself.

For all components built-in, the provisions and safety instructions with regard to the operation and the place of erection and/or installation applying to each of them are to be observed and complied with.

3.6.3 Qualification of the Operating Staff

Only such persons are authorized to commission and connect the module who have an electro-technical special training and who are able to execute the required line connections expertly.

Basic knowledge of the work on PCs and with the current WINDOWS operating system is required to use the software supplied along with the modules. Details about this are contained in the enclosed extensive program description.

4 Preparation of the Product for the Use

4.1 Transport

For the transport of the module, attention has to be to the fact that it is not exposed to any vibrations, heavy shocks as well as jolts and impacts since sensitive components might be damaged by that.

4.2 Packaging

Basically, packaging is to be used for the transport and/or shipment of the module that meets the requirements of the destination and the system and is environmentally acceptable.

Since the module itself has a degree of protection IP00, a transport packing is to be selected that prevents the penetrating of water, dirt, and dust. The inserting of conventional desiccating means in the packaging is recommended.

4.3 Storing

Durable storing: closed rooms, dry, room temperature

4.4 Commissioning

Prior to the commissioning, the following conditions are to be assured and to be checked:

- The expert installation and rating of all necessary electrical connection lines as well as the correct connection of all components to the module.
- The knowledge of the information and instructions given in the present user's manual.

4.4.1 Connection of the DC Link

- The cross section of the wires has to be selected according to the current expected → 1.5mm² are recommended.
- Take into account the polarity.

4.4.2 Connection of the Variable Voltage

- The cross section of the wires has to be selected according to the current expected → 1.5mm² are recommended.
- Take into account the polarity!

4.4.3 Connection of the Power Supply

- 12…30V DC, 1,5mm²
- Observe the polarity!

4.4.4 Connection of the Communication

- 5V DC operating voltage required
- CMOS level → level converter to RS232 level required
- OC_EN must be +5V for operation

4.4.5 Putting the Module into Operation

1. Read the present documentation
2. Connection of the power supply
3. Connection of the communiacation
4. Parameterize
5. Switch it on

5 Operation

5.1 Method of Functioning

The DC/DC converter module can transfer power between a DC link with a voltage of 100V...395V and a side with variable voltage in a bidirectional way. Since several degrees of freedom result from that a more extensive parameterization is required for that purpose. To reach a maximum flexibility in doing this, the control for the DC link voltage and the output voltage is digitally realized.

A PIT1 regulator each exists for the DC link side and the variable voltage side. Depending on the mode of operation, these are linked in a different way. The output value of this linkage is limited to the corresponding maximum values and is output to the hardware (vs_isoll). In addition to that, the I-Components of the regulators are also limited during the limitation so that they do not run up to the maximum values. They are kept at the limiting value so that are contiguous change from one to the other regulator can be executed.

5.1.1 Modes of Operation

Two possibilities are possible for the connection of the output values of the output voltage regulator and the DC-Link voltage regulator (Isoll_V, Isoll_Z).

In the mode of operation 0, the maximum value of the two regulators is used. It is suited for the operation as an output converter i.e. only load flows out of the module into a load or for the application of a buffer store, for example of a double-film capacitor or accumulator. The linkage of the regulators works as follows: If the DC link voltage is bigger than its set desired value, the output voltage regulator is active and keeps vs_uist at a constant level. If the voltage at the DC link drops, the DC link voltage regulator gains the upper hand and tries to keep the DC link voltage at a constant level. The following characteristics result from that for this mode of operation:

- the output voltage is limited upwards and this prevents, for example, an overcharging of the buffer store,
- the DC link voltage is limited downwards and this prevents a collapse of the DC link in case of a too big load.

Voltages	Tendencies	mod_opmode=1	mod_opmode=0
zk_uist < zk_usoll vs_uist < vs_usoll	Isoll_Z ↑ Isoll_V ↓	vs_isoll ↓	vs_isoll ↑
zk_uist > zk_usoll vs_uist < vs_usoll	Isoll_Z ↓ Isoll_V ↓	vs_isoll ↓	vs_isoll ↓
zk_uist < zk_usoll vs_uist > vs_usoll	Isoll_Z ↑ Isoll_V ↑	vs_isoll ↑	vs_isoll ↑
zk_uist > zk_usoll vs_uist > vs_usoll	Isoll_Z ↓ Isoll_V ↑	vs_isoll ↓	vs_isoll ↑

Tab. 2: Behavior in the modes of operation

In the mode of operation 1, the minimum value of the two regulators is used as a current default value. This is favorable for the linking of sources, e.g. of a fuel cell. In this mode of operation, it is prevented that the output voltage falls below the desired value and can thus, for example, damage a fuel-cell stack. Consequently, the voltage regulator of the DC link is usually in operation and keeps the DC link voltage at a constant level. Only when the output voltage falls below the desired value, the output voltage regulator gets active and reduces the current so that it is not possible to fall below the desired value.

Parameter: mod_opmode										
Bit								Dec	Hex	Mode of operation
7	6	5	4	3	2	1	0			
x	x	x	x	x	x	x	0	0	0x00	Output/buffer
x	x	x	x	x	x	x	1	1	0x01	Input
x	x	x	x	0	x	x	x	0	0x00	Normal DC link voltage range 350..400V
x	x	x	x	1	x	x	x	8	0x08	Full DC link voltage range 0..400V
x	0	1	x	x	x	x	x	32	0x20	Automatic mode, VS priority
x	1	1	x	x	x	x	x	96	0x60	Automatic mode, ZK priority
0	x	x	0	x	0	0	x			not used, should always be 0

Tab. 3: Modes of operation

5.1.2 Parallel Connection of Modules at the Variable Voltage Side

To increase the power, it is to be possible to interconnect several DC/DC converter modules at the variable voltage side. But this has the following disadvantage: Since PI regulators are used the output voltage is exactly regulated to meet the desired value. In case of two DC/DC converters connected in parallel, there are, however, always little differences in the voltage references so that one DC/DC converter always accepts the full load until it reaches its current limit. This is unfavorable since the efficiency of the DC/DC converter is just the highest one in the medium power range.

This problem can be solved by a falling current-voltage characteristic. On principle, this one already exists through the resistances of the connecting leads, but too low. The falling characteristic can be obtained in a simple way by a P-regulator for the output voltage. But this is unfavorable here owing to the digital control because strong quantizing jumps in the desired value of the current occur owing to the high necessary amplifications. For that reason, the following arrangement is more favorable:
A PI-regulator is applied as regulator. But the multiple of the desired value of the current is added to the desired value of the voltage that was smoothed before by means of a PT1element with a relatively long time constant. This structure shows then a similar behavior like a voltage source being subject to an internal resistance that is jumpered by a big capacitor. This functionality is provided by the parameters vs_fkkp and vs_fkkt.

On DC link side it is also possible to parameterize a falling characteristic for a better harmonization of the power if two or more modules are connected in parallel. For this, the parameters zk_fkkt and zk_fkkp are available.

5.1.3 Voltage Regulation of the DC Link

Measuring Ranges

For the voltage measurement and regulation of the DC link, there are two voltage-measuring ranges available. These can be switched over by means of bit 3 of the parameter mod-opmode.

If bit 3 is 0, a voltage range of 350V to 400V with a resolution of approx. 0.07V is available. This range recommends itself in connection with other components of the modular converter system of Flexiva.

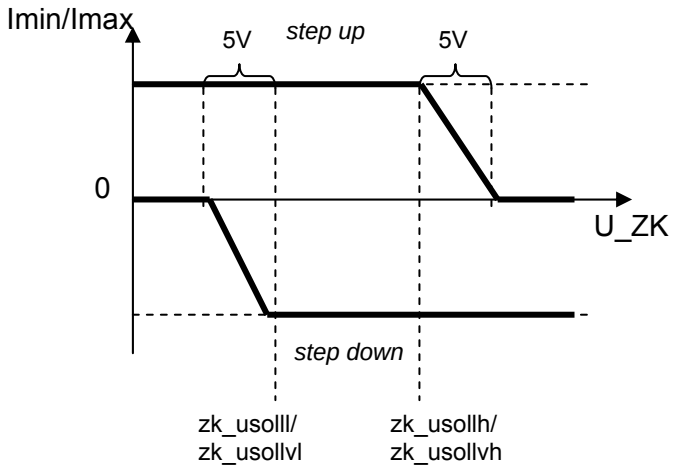
If bit 3 is 1, the full voltage range from 0V to 400V is available but only with a resolution of 0.4V. This range recommends itself if the DC link voltage can become smaller than 355V. In this case, attention has to be paid to the fact that the DC link voltage has to be bigger than the voltage of the variable voltage side (VS side).

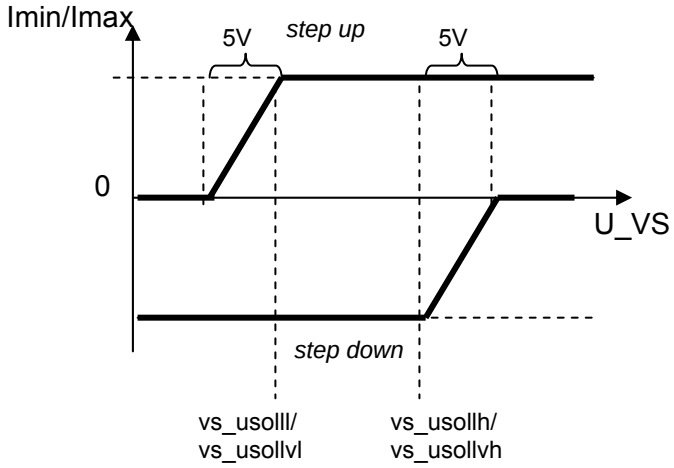
Increasing the amplification outside of a voltage window

It is also possible to define a voltage window. Outside of this window the amplification of the DC link regulator is increased. This is e.g. useful in conjunction with a DC/AC module, to prevent the transmission of DC link ripples to the current of the variable voltage side. The voltage window (parameter zk_uf) is set to the approx. ripple of the DC link voltage and the parameter zk_kv determines the additional increasing outside of the voltage window. The amplifications of the DC link voltage regulator (zk_kp, zk_ki) must be decreased then by this amount.

5.1.4 Undervoltage / Overvoltage Regulator

For both the VS and the ZK voltage there are additional voltage regulators for over-voltage and under-voltage limitation integrated. These are simple P regulators. Within a voltage range of 5V above or below the desired values they automatically reduce the current in the corresponding direction from the maximum possible value down to zero.





5.1.5 Automatic Mode

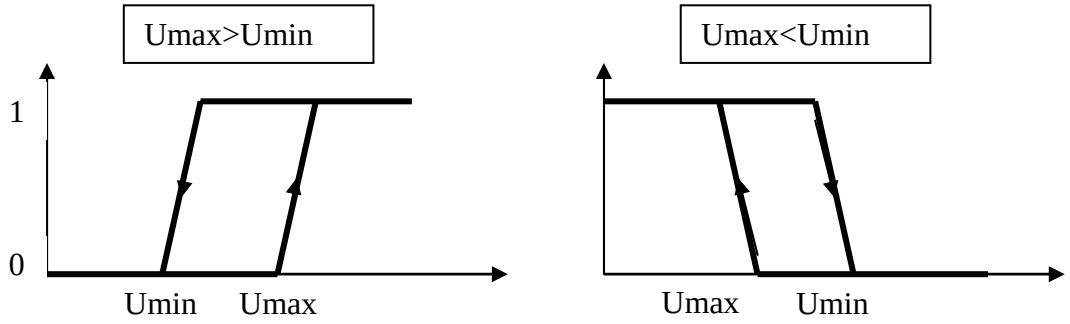
This mode automatically switches the module on ore off in the dependency of the VS- and the ZK-voltage. It can be enabled by means of bit 5 of the parameter mod_opmode.

The on-/off- set points are set with the parameters zk_umax_g, zk_umin_g, vs_umax_g and vs_umin_g, where the …umax… are the switching on set points, the …umin…are the switching off set points.

Two operating modes are possible. If …umax…>…umin…, the module is switched on if the voltage exceeds …umax… and is switched off if the voltage is below …umin… . This can be used for switching off the module in the case of under voltage shutoffs.

If …umax…<…umin…, the module is switched on if the voltage is below …umax… and is switched off if …umin… is exceeded. This mode can be used for switching off the module in the case of charging end shutoffs.

Because the modes of the ZK and the VS voltage can be used at the same time, a priority must be determined. It defines what should happen if the one comparison results in turning on and the other results in turning off the module.



Bit 6 of the parameter mod_opmode is used to determine, whether the VS side or the ZK side has the prior. If bit 6 is 0, the VS side has the prior. If bit 6 is 1, the ZK side has the prior.

Priority VS: Bit 6 = 0

comparison ZK	**ON**	**x**	**OFF**
comparison VS			
ON	ON	ON	ON
x	ON	x	OFF
OFF	OFF	OFF	OFF

Priority ZK: Bit 6 = 1

comparison ZK	**ON**	**x**	**OFF**
comparison VS			
ON	ON	ON	OFF
x	ON	x	OFF
OFF	ON	OFF	OFF

In the automatic mode all errors are resetted automatically after 3 seconds.

5.1.6 Virtual Capacitor

By means of the parameter set for the virtual capacitor functionality, the module can be parameterized so that the output voltage can be imaged on the desired value of the DC link voltage. If you connect, for example, a double-film capacitor to the output

of a module the voltage of this capacitor changes along with its charging condition, too. This voltage is collected by the module, can be equipped with an offset (zk_vcko), is then amplified (zk_vckp), and possible filtered (zk_vckt) (Fig. 5).

5.1.7 Monitoring Functions / Shutdowns on Faults

The module is equipped with numerous monitoring functions that are explained in the following. If there is a fault shutdown executed, the corresponding bits (see table below) are set in the variable mod_state. Before the module can be restarted, the faults occurred have to be acknoweldged by setting the variable err_quit to 1.

Overcurrent

→ "I_VS too high"

Is indicated when the hardware overcurrent shutdown was activated.

Overtemperature

→ "Overtemperature“

For the overtemperature shutdown, the temperature of the heat sink element is monitored. At a temperature of more than 90 °C at the heat sink element, the shutdown is carried out with an error message.

Overvoltage at the DC link

→ "U_ZK too high“

If the DC link voltage exceeds 400V, there is a fault shutdown carried out.
In the full range DC link voltage mode, there is an additional shutdown carried out if the DC link voltage exceeds the value 1,5*zk_usollvh.

Undervoltage at the DC link

→ "U_ZK too low“

In the normal range DC link voltage mode, there is a shutdown carried out because of DC link undervoltage at 351V.

In the full range DC link voltage mode a shutdown is carried out if the DC link voltage is smaller than 6V below the bottom desired value zk_usollvl.

If during the initial charging of an empty DC link the desired DC link voltage is not reached after a certain period, the module also shuts down with an error message.

Voltage Range Error

→ „Voltage Ranges exceeded“

Due to the principle the voltage of the variable voltage side (VS side) ever has to be smaller than the DC link voltage. If this condition is not fullfilled and the variable voltage exceeds 95% of the DC link voltage, this error occurs.

Overvoltage / Undervoltage at the VS side

→ „U_VS too low/high“

If the vs_uist is 10V below the vs_uminmin or 10V above the vs_umaxmax, this error occurs.

Hardware Error

→ "Hardware error“

A hardware error either occurs when there has a problem in the power supply of the module occurred or when the overvoltage shutdown of the DC link of another module was triggert and the signal OC_EN is low at the communication interface.

All errors are stored in the variable mod_state and have to be acknowledged and consequently reset by putting err_quit to 1.

parameter: mod_state												
Bit								Dec	Hex	status	Reaction of the system	Restart when error eliminated
7	6	5	4	3	2	1	0					
0	0	0	0	0	0	0	0	0	0x00	no error		
0	0	0	0	0	0	0	1	1	0x01	not used		
0	0	0	0	0	0	1	0	2	0x02	U_ZK too low	shutdown, err_quit=0	err_quit=1
0	0	0	0	0	1	0	0	4	0x04	Hardware Error	shutdown, err_quit=0	err_quit=1
0	0	0	0	1	0	0	0	8	0x08	Voltage Ranges exceeded	shutdown, err_quit=0	err_quit=1
0	0	0	1	0	0	0	0	16	0x10	Overtemperature	shutdown, err_quit=0	err_quit=1
0	0	1	0	0	0	0	0	32	0x20	I_VS too high	shutdown, err_quit=0	err_quit=1
0	1	0	0	0	0	0	0	64	0x40	U_VS too low / high	shutdown, err_quit=0	err_quit=1
1	0	0	0	1	0	0	0	128	0x80	U_ZK too high	shutdown, err_quit=0	err_quit=1

Tab. 4: Error codes

5.1.8 Empty DC Link

If the module is switched on with an empty DC link and a voltage is connected to the VS side, so firstly it takes place a precharging of the DC link by pre-charging PTC resistors. If the precharging is successful, the main relais is switched on and the converter is startet with a reduced current of 1A. Is the DC link charged and the desired DC link voltage is reached, this limitation is cancelled.
If the precharging of the DC link is not successful, because the PTC resistors overheat due to large capacities or a load at the DC link, the module switches off with an error after 10s. The error is “U_ZK too low”.

5.2 Basic Parameterization

The module can only be parameterized by means of the serial interface. It is, however, more convenient to do this by means of the software belonging to it.

R readable

W writable (parameterizable)

E stored in the EEPROM (EEP)

B can be changed in switched-on state (mod_on=1)

5.2.1 Currents: variable voltage Side (VS side)

Scalings			
Type of module	**Range of values**	**Communication values**	**Resolution**
350V2	-10…10A	-1000…1000	10mA

parameter	**vs_imin**	
description	current, minimum	
explanation	minimum of the desired current	
instruction	wj	**RW B**

parameter	**vs_imax**	
description	current, maximum	
explanation	minimum of the desired current	
instruction	wi	**RW B**

parameter	**vs_imin_f**	
description	current, minimum, initial value in EEPROM	
explanation	vs_imin receives this value directly after initial operation of the module through connection of the operation voltage	
instruction	wl	**RW E**

parameter	**vs_imax_f**	
description	current, maximum, initial value in the EEP	
explanation	vs_imax receives this value directly after initial operation of the module through connection of the operation voltage	
instruction	wk	**RW E**

parameter	**vs_imin_g**	
description	current, lower limit	
explanation	not used	
instruction	wn	**RW E**

parameter	**vs_imax_g**	
description	current, upper limit	
explanation	not used	
instruction	wm	**RW E**

parameter	**vs_iminmax**	
description	current, switch-off value	
explanation	not used	
instruction	wg	**RW E**

parameter	**vs_iist**	
description	current, actual value	
explanation	measured current of the VS side; is normally the same value as the desired value vs_isoll	
instruction	wa	**R**

parameter	**vs_isoll**	
description	current, desired value	
explanation	output value of the regulator that is transferred to the hardware as the desired value of the current; is normally adjusted	
instruction	wb	**R**

5.2.2 Voltages: variable voltage side (VS side)

Scalings			
Type of module	**Range of values**	**Communication values**	**Resolution**
350V2	0…380 V	0…3800	406 mV

parameter	**vs_umax_g**	
description	voltage, upper limit	
explanation	only used in automatic mode	
instruction	vm	**RW E**

parameter	**vs_umin_g**	
description	voltage, lower limit	
explanation	only used in automatic mode	
instruction	vn	**RW E**

parameter	**vs_umaxmax**	
description	voltage, switch-off value, upper limit	
explanation	if actual value is above -> error shutdown	
instruction	vo	**RW E**

parameter	**vs_uminmin**	
description	voltage, switch-off value, lower limit	
explanation	if actual value is below -> error shutdown	
instruction	vp	**RW E**

parameter	**vs_usoll_f**	
description	voltage, desired initial value in EEPROM	
explanation	vs_usoll receives this value directly after initial operation of the module through connection of the operation voltage	
instruction	vv	**RW E**

parameter	**vs_usoll**	
description	voltage, desired value	
explanation	desired value at the VS side	
instruction	vu	**RW B**

parameter	**vs_usollh_f**	
description	voltage, upper limiter, initial value in EEPROM	
explanation	vs_usollh receives this value directly after initial operation of the module through connection of the operation voltage	
instruction	ve	**RW E**

parameter	**vs_usollh**	
description	voltage, upper limiter	
explanation	desired value of the upper limit regulator	
instruction	vd	**RW B**

parameter	**vs_usolll_f**	
description	voltage, lower limiter, initial value in EEPROM	
explanation	vs_usolll receives this value directly after initial operation of the module through connection of the operation voltage	
instruction	vg	**RW E**

parameter	**vs_usolll**	
description	voltage, lower limiter	
explanation	desired value of the lower limit regulator	
instruction	vf	**RW B**

parameter	**vs_uist**	
description	voltage, actual value	
explanation	actual voltage at the VS side; if the main relay is energized: voltage at the converter output, otherwise: voltage at the terminals	
instruction	va	**R**

parameter	**vs_uista**	
description	voltage, actual value	
explanation	actual voltage at the VS side; voltage at the converter output	
instruction	vb	**R**

parameter	**vs_uistn**	
description	voltage, actual value	
explanation	actual voltage at the VS side; voltage at the terminals	
instruction	vc	**R**

5.2.3 Voltages: DC link (ZK Side)

Normal voltage range

parameter	**zk_usoll**	
description	voltage, desired value	
explanation	desired value of the DC link voltage scaling: 350V…400V -> 3500…4000	
instruction	zu	**RW B**

parameter	**zk_usoll_f**	
description	voltage, desired initial value in EEPROM	
explanation	zk_usoll receives this value directly after initial operation of the module through connection of the operation voltage	
instruction	zv	**RW E**

parameter	**zk_usollh**	
description	voltage, upper limiter,	
explanation	desired value of the upper limit regulator scaling: 350V…400V -> 3500…4000	
instruction	zd	**RW B**

parameter	**zk_usollh_f**	
description	voltage, upper limiter, initial value in EEPROM	
explanation	zk_usollh receives this value directly after initial operation of the module through connection of the operation voltage	
instruction	ze	**RW E**

parameter	**zk_usolll**	
description	voltage, lower limiter,	
explanation	desired value of the lower limit regulator scaling: 350V…400V -> 3500…4000	
instruction	zf	**RW B**

parameter	**zk_usolll_f**	
description	voltage, lower limiter, initial value in EEPROM	
explanation	zk_usolll receives this value directly after initial operation of the module through connection of the operation voltage	
instruction	zg	**RW E**

parameter	**zk_uist**	
description	voltage, actual value resolution: 0V…350V: 0.4 V resolution: 350V…400V: ca. 0.07V	
explanation	scaling: 0V…400V -> 0…4000	
instruction	za	**R**

Full voltage range

parameter	**zk_usollv**	
description	voltage, desired value	
explanation	desired value of the DC link voltage scaling: 0V…400V -> 0…4000	
instruction	zq	**RW B**

parameter	**zk_usollv_f**	
description	voltage, desired initial value in EEPROM	
explanation	zk_usollv receives this value directly after initial operation of the module through connection of the operation voltage scaling: 0V…400V -> 0…4000	
instruction	zr	**RW E**

parameter	**zk_usollvh**	
description	voltage, upper limiter,	
explanation	desired value of the upper limit regulator scaling: 0V…400V -> 0…4000	
instruction	zh	**RW B**

parameter	**zk_usollvh_f**	
description	voltage, upper limiter, initial value in EEPROM	
explanation	zk_usollvh receives this value directly after initial operation of the module through connection of the operation voltage	
instruction	zi	**RW E**

parameter	**zk_usollvl**	
description	voltage, lower limiter,	
explanation	desired value of the lower limit regulator scaling: 0V..400V -> 0..4000	
instruction	zj	**RW B**

parameter	**zk_usollvl_f**	
description	voltage, lower limiter, initial value in EEPROM	
explanation	zk_usollvl receives this value directly after initial operation of the module through connection of the operation voltage	
instruction	zk	**RW E**

parameter	**zk_uist**	
description	voltage, actual value resolution: 0V…400V: 0.4 V	
explanation	scaling: 0V…400V -> 0…4000	
instruction	zb	**R**

Normal / Full voltage range

Parameter	**zk_umax_g**	
Beschreibung	voltage, upper limit	
Erläuterung	only used in automatic mode scaling: 0V…400V -> 0…4000	
Befehl	zm	**RW E**

Parameter	**zk_umin_g**	
Beschreibung	voltage, lower limit	
Erläuterung	only used in automatic mode Skalierung: 0V…400V -> 0…4000	
Befehl	zn	**RW E**

5.2.4 Information

parameter	**mod_state**	
description	module, status	
explanation	error codes, see Tab. 4	
instruction	is	**R**

parameter	**mod_opmode**	
description	module, operating mode	
explanation	operating modes	
instruction	im	**RW E**

parameter	-	
description	module, type	
explanation	module type: 350V2	
instruction	it	**R**

parameter	-	
description	module, firmware	
explanation	software version of the firmware	
instruction	if	**R**

parameter	-	
description	module, serial number	
explanation	serial number of the manufacturer	
instruction	in	**R**

parameter	-	
description	module, date of manufacture	
explanation	date of manufacture	
instruction	id	**R**

parameter	**t_kk**	
description	temperature, heat sink	
explanation	scaling: -112…160°C -> -1120…1600	
instruction	tk	**R**

parameter	**t_trafo**	
description	temperature, transformator	
explanation	not used	
instruction	tt	**R**

5.2.5 Commands

parameter	**mod_on**	
description	module on / off	
explanation	1: on 0: off	
instruction	ce	**RW B**

parameter	**err_quit**	
description	acknowledge an error	
explanation	1: acknowledging the error	
instruction	cq	**RW B**

parameter	**com_mode**	
description	communication mode	
explanation	0: ASCII short 1: ASCII long	
instruction	cc	**R B**

5.2.6 Oscilloscope

For the setting of the regulator parameters and for the observing in the operation, an oscilloscope functionality is integrated into the software. By means of it voltages and current can be recorded. 13 channels with 512 values each with a scope of values of 16bit are recorded. The possible scanning frequency is in the range from 9.654 kHz and 37.9 Hz.

The channel where triggering is done can be selected independently of the recorded channel.

The values are not scaled, i.e. they are internal operands.

Ch		Description	Scaled range	Real range
0	**zk_uist**	DC link voltage normal voltage range	5280 6040	350V 400V
1	**zk_uist_v**	DC link voltage full voltage range	0 +4000	0V +400V
2	**pwm_soll_glob**	PWM desired value	0 +1408	0% +100%
3	**vs_uistn**	voltage at the output terminals	0 +3892	0V +400V
4	**vs_uista**	voltage at the converter output, VS side	0 +3892	0V +400V
5	**l1_iist**	output current	-2120 1976	-19.9A +18.5A
6	**n.u.**	not used	-	-
7	**vs_usoll**	voltage, desired value	0 3892	0V 400V
8	**vs_isoll**	current, desired value	-2120 2120	-19.9A +19.9A
9	**vs_isollv**	output VS voltage regulator	-2120 2120	-19.9A +18.5A
10	**vs_isollz**	output ZK voltage regulator	-2120 2120	-19.9A +19.9A
11	**n.u.**	not used	-	-
12	**l1_soll_glob**	Voltage, desired value for the Modulator	0 3892	-400V 400V

parameter	**osz_ch**	
description	channel	
explanation	parameter range: 0…12	
instruction	ok	**RW B**

parameter	**osz_ft**	
description	frequency divider	
explanation	clock: 9.654kHz/osz_ft 0 corresponds to 9.654kHz/256	
instruction	of	**RW B**

parameter	**osz_tr**	
description	trigger value	
explanation	Parameter range depends on the selected channel	
instruction	ot	**RW B**

parameter	**osz_tch**	
description	trigger channel	
explanation	parameter range: 0…12	
instruction	oc	**RW B**

parameter	**osz_m**	
description	storage mode	
explanation	see Tab. 5	
instruction	om	**RW B**

parameter: osz_m										
Bit								**Dec**	**Hex**	**meaning**
7	**6**	**5**	**4**	**3**	**2**	**1**	**0**			
x	x	x	x	x	x	x	0	0	0x00	trigger at: value > trigger value
x	x	x	x	x	x	x	1	1	0x01	trigger at: value < trigger value
x	x	x	0	0	x	x	x	0	0x00	trigger position 0 %
x	x	x	0	1	x	x	x	8	0x08	trigger position 25%
x	x	x	1	0	x	x	x	16	0x10	trigger position 50%
x	x	x	1	1	x	x	x	24	0x18	trigger position 75%

Tab. 5: Modes of operation of oscilloscope

parameter	**osz_on**	
description	oscilloscope on / off	
explanation	start/stop; status	
command	oe	**RW B**

parameter	**-**	
description	read data, only the channel osz_ch	
explanation	reads the 512 values (ASCII, separated by 0x0D 0x0A)	
command	or	**R**

parameter	-	
description	read data, all channels	
explanation	reads all the values of all channels (ASCII, separated by blank, end of line: 0x0D)	
command	os	**R**

parameter: osz_on										
Bit								Dec	Hex	meaning
7	6	5	4	3	2	1	0			
x	x	x	x	x	x	x	0	0	0x00	not running
x	x	x	x	x	x	x	1	1	0x01	runs, waits for trigger
x	x	x	x	x	x	1	x	2	0x02	runs, triggered
x	x	x	x	x	1	x	x	4	0x04	runs, forerun before trigger

Tab. 6: Status values of oscilloscope

5.3 Regulator Setting

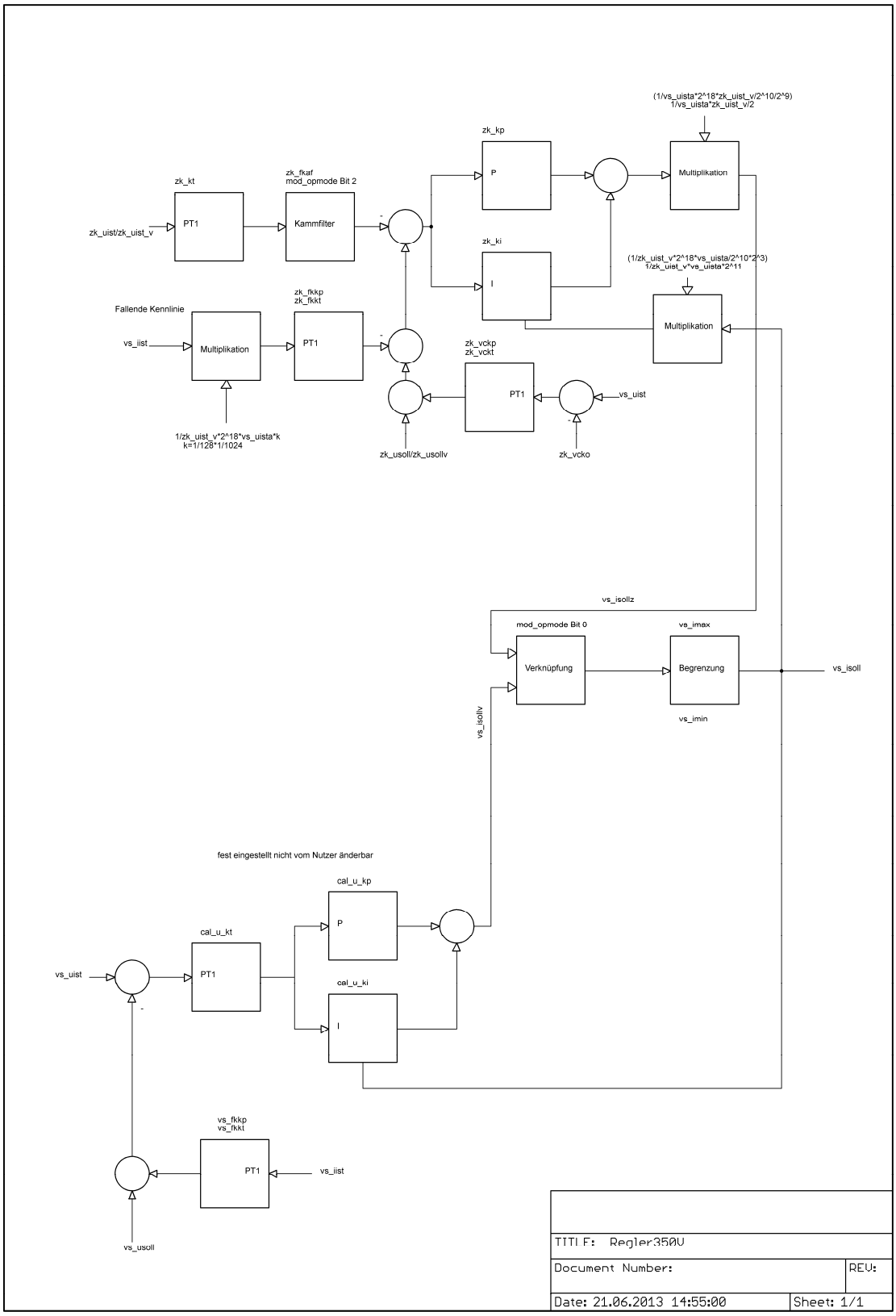


Fig. 5: Block diagram of the voltage regulators

5.3.1 Parameters of the VS-Regulator

The VS-sided voltage regulator is pre-configured. The parameters can not be changed.

parameter	**vs_fkkp**	
description	falling characteristics, amplification	
explanation	parameter range: 0…1023 v=(42V/A)/1024*vs_fkkp	
command	uk	**RW E**

parameter	**vs_fkkt**	
description	falling characteristics, time constant	
explanation	parameter rane: 0…1023 transfer function: G=1/(1+pT) T: 106ms…0.103ms T=1024/(vs_fkkt*9655Hz)	
command	uz	**RW E**

5.3.2 Parameters of the ZK-Regulator

Basic amplification (not shown in the block diagram) ???

parameter	**zk_ki**	
description	regulator, I-component	
explanation	parameter rane: 0…1023 transfer function: G=V_I/p V_I: 0…???s^{-1} V_I=???s^{-1}/1023*zk_ki	
command	yi	**RW E**

parameter	**zk_kp**	
description	regulator, P-component	
explanation	parameter rane: 0…1023 amplification: 0…4	
command	yp	**RW E**

parameter	**zk_kt**	
description	regulator, time constant	
explanation	parameter rane: 0…1023 transfer function: G=1(1+pT) T: 212ms…0.21ms T=1024/(zk_kt*4828Hz)	
command	yt	**RW E**

parameter	**zk_vckp**	
description	virtual capacitor, amplfication	
explanation	parameter rane: 0…1023 v=1.29/1024*zk_vckp (normal voltage range) v=1.94/1024*zk_vckp (full voltage range)	
command	yk	**RW E**

parameter	**zk_vckt**	
description	virtual capacitor, time constant	
explanation	parameter range: 0…255 transfer function: G=1(1+pT) T: 212ms…0.21ms T=1024/(zk_kt*4828Hz))	
command	yz	**RW E**

parameter	**zk_vcko**	
description	virtual capacitor, offset	
explanation	corresponds to the voltage at the VS-side 350V2-module: 0…3500	
command	yo	**RW E**

parameter	**zk_fkkp**	
description	falling characteristics, amplification	
explanation	parameter range: 0…255 amplification: 0…10.2V/A (normal voltage range) 0…6.8V/A (full voltage range)	
command	yl	**RW E**

parameter	**zk_fkkt**	
description	falling characteristics, time constant	
explanation	parameter range: 0…1024 transfer function: G=1(1+pT) T: 212ms…0.21ms T=1024/(zk_kt*4825Hz)	
command	yu	**RW E**

parameter	**zk_uf**	
description	voltage window	
explanation	parameter range: 0…150 voltage range: 0…±10V (normal voltage range), 0…±15V (full voltage range)	
command	yf	**RW E**

parameter	**zk_kv**	
description	voltage window, amplification outside	
explanation	parameter range: 0…255 amplification: 0…16	
command	yv	**RW E**

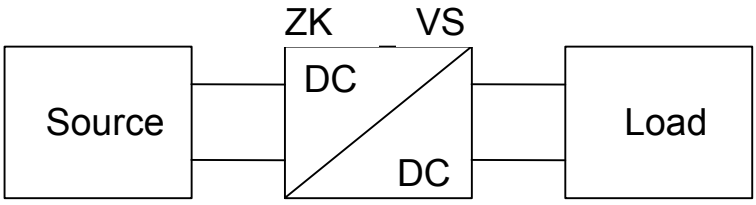
5.4 Typical Cases of Application / Parameterization Examples

To be able to operate the DC/DC converter module in a certain arrangement, some parameters have to be placed correctly. In the following example configurations, useful instructions are given for the correct parameterization.

Apart from the basic parameters mod_opmode, vs_imax, vs_imin, vs_usoll, zk_usoll, it is also recommended to modify the regulator parameters and to use only a P-regulator instead of a PI-regulator under certain conditions.

Attention

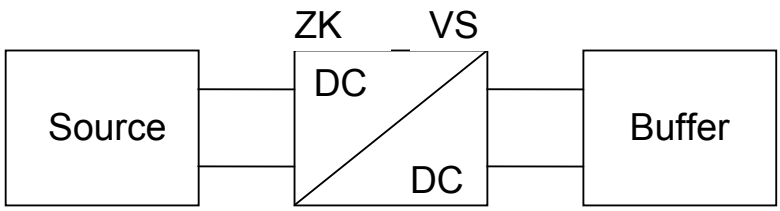
During the initial charging of the DC link it must be unloaded, i.e. there have to be no additional electrical capacities and / or electrical loads connected to the DC link.

a)		
Application	possible sources: DC network, PFC possible load: any load you like	
Parameter	mod_opmode:	0
	vs_imax:	0 respectively >0
	vs_imin:	- desired current limit
	zk_usoll:	desired value DC link voltage, smaller than minimally occurring DC link voltage
	vs_usoll:	desired output voltage

In this case of application, the module works like a typical power supply: it keeps the output voltage on the desired value vs_usoll at a constant level and limits the current in case of overload to vs_imin. (Attention: vs_imin is negative since the current direction is defined inside the module.) The parameter vs_imax should be on 0 so that no current can flow into the module. In some cases, this can, owing to offset errors, lead to the fact that the voltage ramps-up when no load is connected. In this

case, it is recommended to give vs_imax a small positive value of approx. 1..3A to ensure that the voltage can be kept at the desired value.

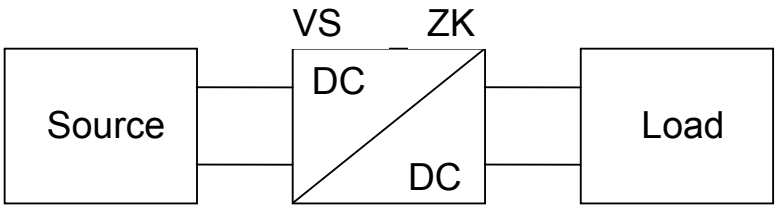
The parameter zk_usoll is the desired value for the DC link voltage. If it falls below the value, the voltage regulator of the DC link tries to maintain the same by preventing that power flows from the DC link to the variable voltage side. This means that the output voltage collapses in case of overload. If this is not desired and a hard shutdown is to be carried through in case of overload instead of that, zk_usoll is to be put onto the minimally possible value 3,500 (corresponds to 350V). If the DC link voltage collapses now the regulator cannot intervene and the module switches off because of a too low DC link voltage.

b)		
Application	buffering of a DC link e.g. by means of an accu or supercap	
Parameter	mod_opmode:	0
	vs_imax:	+ desired current limit
	vs_imin:	- desired current limit
	zk_usoll:	desired value DC link voltage
	vs_usoll:	max. back-up voltage

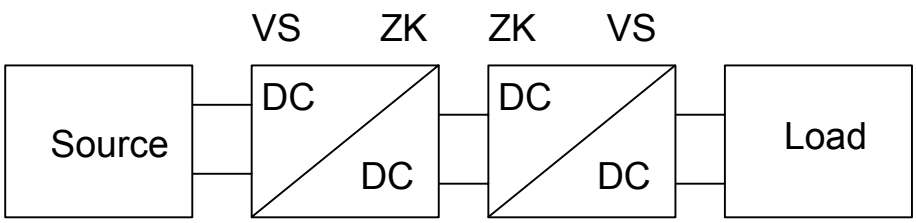
This arrangement serves to buffer a DC link. The maximum current flowing into the module, i.e. the buffer-discharging current is fixed by means of vs_imax, the maximum current flowing out of the module, the buffer-charging current, is fixed by vs_imin. The parameter vs_usoll serves to limit the back-up voltage upwards. If you also want to limit the buffer-discharging voltage downwards, you can realize this with the help of the parameter vs_uminmin – but here, a deviation of 1/120 of the voltage range of the variable voltage is to be taken into account.

Now the voltage regulator of the DC link keeps the voltage on the desired value zk_usoll at a constant level. If the DC link voltage exceeds the desired value, the

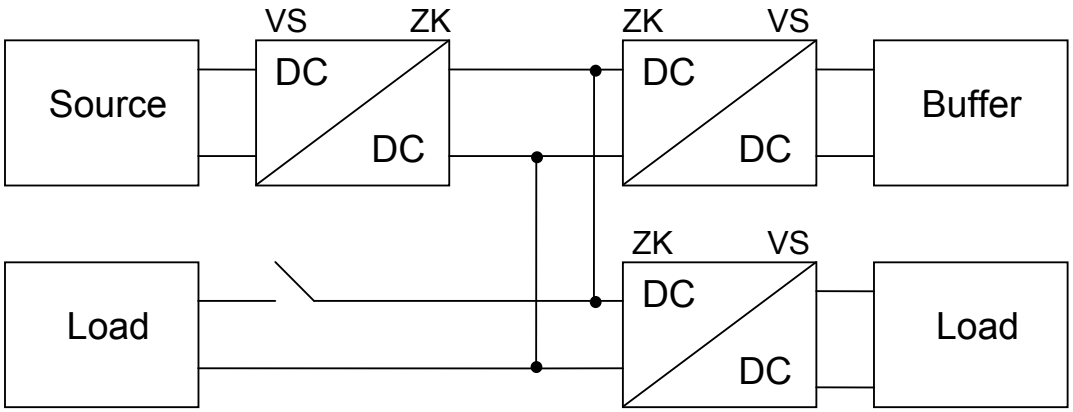
buffer store is charged, if it falls below the desired level, it is discharged. You can reach a softer behavior that offers itself, for example, in case of pulsating DC link voltages if you parameterize the voltage regulator of the DC link as a P-regulator.

c)		
Application	possible sources: fuel cell, accu possible loads: chopper-type power supply unit, motor power converter, inverter	
Parameter	mod_opmode:	1
	vs_imax:	+ desired current limit
	vs_imin:	0
	zk_usoll:	desired value DC link voltage
	vs_usoll:	smaller than minimum input voltage

Another imaginable case of application is the generation of a high DC link voltage from a source with a low voltage. By the selection of mod_opmode=1, it is reached that the voltage regulator of the DC link is active for vs_uist > vs_usoll and regulates the DC link voltage to the desired value. The regulator of the variable voltage only intervenes when the value is less than the value vs_usoll on the variable voltage side and prevents an undervoltage at the source. If the load remains unchanged in this case, the DC link voltage drops and results in the shutdown.

d)		
Application	any application you like, disadvantage: low efficiency	
Parameter module to source	mod_opmode:	1
	vs_imax:	+ desired current limit
	vs_imin:	0
	zk_usoll:	desired value DC link voltage
	vs_usoll:	smaller than minimum input voltage
Parameter module to load	mod_opmode:	0
	vs_imax:	0 respectively >0
	vs_imin:	- desired current limit
	zk_usoll:	desired value DC link voltage, smaller than minimally occurring DC link voltage
	vs_usoll:	desired output voltage

This case is the interconnection of configuration a) and configuration c). During the switching-on, you have to comply with the following sequence of operations: switch-on the module at the source, wait until the DC link is loaded, switch-on the module at the load.

e)		
application	full system comprising source, load, and buffer store	
Parameter module to source	mod_opmode:	1
	vs_imax:	+ desired current limit
	vs_imin:	0
	zk_usoll:	desired value DC link voltage
	vs_usoll:	smaller than minimum input voltage
Parameter module to buffer	mod_opmode:	0
	vs_imax:	+ desired current limit
	vs_imin:	- desired current limit
	zk_usoll:	desired value DC link voltage
	vs_usoll:	max. back-up voltage
Parameter module to load	mod_opmode:	0
	vs_imax:	0 respectively >0
	vs_imin:	- desired current limit
	zk_usoll:	desired value DC link voltage, smaller than minimally occurring DC link voltage
	vs_usoll:	desired output voltage

On principle, this case is an interconnection of the arrangements a) to c). But there are several possibilities of the power distribution.

In the simplest case, you parameterize $zk\_usoll_{load} < zk\_usoll_{buffer} < zk\_usoll_{source}$. If the load is bigger than the source is able to supply (variable voltage is limited downwards), the DC link voltage collapses and the converter at the buffer store keeps it at its desired value. When the load gets smaller again, the converter at the source remains in the mode voltage control of the variable voltage while the buffer store is able to refills. As soon as the buffer store is full, the variable voltage regulator takes effect at the buffer store and limits the back-up voltage upwards. To limit the current rise at the source in this mode of operation, e.g. to protect a fuel cell, the delay of the voltage regulator of the DC link is to be increased, i.e. a smaller value of zk_kt has to be selected.

Another possibility is the utilization of the mode of operation “Virtual capacitor”. Because of that, a continuous waveshape of the DC link voltage is reached proportionally to the fill level of the buffer store. The DC/DC converter at the load draws again the power from the DC link. The buffer store converter keeps the DC link voltage at a constant level by means of a PI-regulator. But now the desired value for the DC link voltage is changed depending on the charging condition of the buffer store. The less the buffer store is charged the lower the DC link voltage gets. The DC/DC converter module at the source has got now a P-regulator with delay to smooth the desired value. If the DC link voltage now gets lower, this DC/DC converter supplies more power. If the load gets less now, more power flows into the buffer store, this leads to a rise of the DC link voltage and the power drawn from the fuel cell decreases.

The third possibility is the control of the power flow by means of a higher-level control (internally or externally). In such a system, the buffer store keeps the DC link voltage at a constant level, the higher-level control monitors the charging condition of the buffer store and triggers the source on this basis. This way, the combination of several sources and buffers (e.g. long-term and short-term storage devices) is possible.

5.5 Error Treatment

Acknowledging of the error, eliminating of the cause, restarting.

6 Programming / Parameterization

6.1 Preliminary Remarks

The DC/DC module offers a convenient software interface. All parameters / commands / measured values can be written and/or read by means of a simple ASCII protocol. All module variables no matter whether they represent a parameter, a measured value or a command are addressable by means of an instruction code consisting of two characters. The first character indicates the respective group membership, e.g. "z" for the voltage parameters of the DC link and the second character then specifies the concrete variable. A complete list of all instruction codes is part of the present documentation.

The serial interface of the modules serves as (hardware) communication interface. It can, for example, be connected with the RS232 interface of a PC. The following settings are required:

bits per second	115200
data bits	8
parity	none
stop bits	1
flow control	none

Tab. 7: Settings RS232

6.2 The ASCII Protocol used

The transfer of the corresponding commands in the ASCII format is done in a simple scheme. All characters transferred to the module are immediately evaluated by the same and checked with regard to their validity within the respective sequence of commands. This means concretely: If, for example, a plus/minus sign is expected at a certain point of a sequence of commands, the module only accepts the signs plus(+) or minus(-). Valid characters are directly mirrored (exceptions: control characters for the protocol changeover and CR), invalid characters are immediately rejected. With the aid of this procedural method, a complex and extensive protocol (checksums, length specifications etc.) can be avoided and, nevertheless, faulty insertions can be minimized.

From firmware 2.06 on, a protocol with checksum is available (see further chapter).

6.2.1 Read / write without checksum

Basically, you have to distinguish between "Reading" and "Writing" as far as the sequences of instructions to be sent to the module are concerned. If, for example, the value stored in a module variable is only to be read, you have to send the corresponding command code as a sequence followed by Return. If a new value is to be stored in a variable, the corresponding command code, the plus/minus sign of the new value, the new value itself and Return are to be sent.

Read	Write
Command code + CR	Command code + sign + new value + CR

Tab. 8: Command sequences without checksum in general

6.2.2 Read / write with checksum

Basically, you have to distinguish between "Reading" and "Writing" as far as the sequences of instructions to be sent to the module are concerned. If, for example, the value stored in a module variable is only to be read, you have to send the corresponding command code as a sequence followed by Return. If a new value is to be stored in a variable, the corresponding command code, the plus/minus sign of the new value, the new value itself, the checksum and Return are to be sent.

Read	Write
Command code + Σ + CR	Command code + sign + new value + Σ + CR

Tab. 9: Command sequences with checksum in general

The following table lists all possible command codes for the communication with the module and they are arranged in groups. At the same time, the names of the respective module variables as well as the place of storing and the parameterability are shown.

Group	Description	1. Command Character	2. Command Character	parame-trizable	EEP	Parameter
DC link	voltage, normal range: upper limiter, desired value	z	d	x+		zk_usollh
(Dc link side)	voltage, normal range: upper limiter, desired initial value in EEPROM	z	e	x	x	zk_usollh_f
	voltage, normal range: desired value	z	u	x+		zk_usoll
	voltage, normal range: desired initial value in EEPROM	z	v	x	x	zk_usoll_f
	voltage, normal range: lower limiter, desired value	z	f	x+		zk_usolll
	voltage, normal range: lower limiter, desired initial value in EEPROM	z	g	x	x	zk_usolll_f
	voltage, normal range: actual value	z	a			zk_uist
	voltage, full range: upper limiter, desired value	z	h	x+		zk_usollvh
	voltage, full range: upper limiter, desired initial value in EEPROM	z	i	x	x	zk_usollvh_f
	voltage, full range: desired value	z	q	x+		zk_usollv
	voltage, full range: desired initial value in EEPROM	z	r	x	x	zk_usollv_f
	voltage, full range: lower limiter, desired value	z	j	x+		zk_usollvl
	voltage, full range: lower limiter, desired initial value in EEPROM	z	k	x	x	zk_usollvl_f
	voltage, full range: actual value	z	b			zk_uistv
	voltage: upper limit (only used in automatic mode)	z	m	x	x	zk_umax_g
	voltage: lower limit (only used in automatic mode)	z	n	x	x	zk_umin_g
	regulator: I-component	y	i	x	x	zk_ki
	regulator: P-component	y	p	x	x	zk_kp
	regulator: time constant	y	t	x	x	zk_kt
	virtual capacitor: amplification	y	k	x	x	zk_vckp
	virtual capacitor: time constant	y	z	x	x	zk_vckt
	virtual capacitor: offset	y	o	x	x	zk_vcko
	falling characteristics: amplification	y	l	x	x	zk_fkkp
	falling characteristics: time constant	y	u	x	x	zk_fkkt
	voltage window	y	f	x	x	zk_uf
	voltage window: amplification outside	y	v	x	x	zk_kv
Variable voltage	current: switch-off value (not used)	w	g	x	x	vs_iminmax
(component side)	current: maximum	w	i	x+		vs_imax
	current: maximum, initial value in EEPROM	w	k	x	x	vs_imax_f
	current: minimum	w	j	x+		vs_imin
	current: minimum, initial value in EEPROM	w	l	x	x	vs_imin_f
	current: upper limit (not used)	w	m	x	x	vs_imax_g
	current: lower limit (not used)	w	n	x	x	vs_imin_g
	current: desired value (from the regulator)	w	b			vs_isoll
	current: actual value (measured value)	w	a			vs_iist
	voltage: switch-off value, upper limit	v	o	x	x	vs_umaxmax
	voltage: switch-off value, lower limit	v	p	x	x	vs_uminmin
	voltage: upper limiter, desired value	v	d	x+		vs_usollh
	voltage: upper limiter, desired initial value in EEPROM	v	e	x	x	vs_usollh_f
	voltage: desired value	v	u	x+		vs_usoll
	voltage: desired initial value in EEPROM	v	v	x	x	vs_usoll_f
	voltage: lower limiter, desired value	v	f	x+		vs_usolll
	voltage: lower limiter, desired initial value in EEPROM	v	g	x	x	vs_usolll_f
	voltage: actual value (if mod_on=1: vs_uista; else: vs_uistn)	v	a			vs_uist
	voltage: actual value (value measured at the converter)	v	b			vs_uista
	voltage: actual value (value measured at the terminals)	v	c			vs_uistn
	voltage: upper limit (only used in automatic mode)	v	m	x	x	vs_umax_g
	voltage: lower limit (only used in automatic mode)	v	n	x	x	vs_umin_g
	falling characteristics: amplification	u	k	x	x	vs_fkkp
	falling characteristics: time constant	u	z	x	x	vs_fkkt
Temperature	heat sink	t	k			t_kk
	transformator (not used)	t	t			t_trafo
Info	module state	i	s			mod_state
	module operating mode	i	m	x	x	mod_opmode
	module type	i	t			
	module firmware	i	f			
	module serial number	i	n		x	
	module date of manufacture	i	d		x	
Commands	module on / off	c	e	x+		mod_on
	error quit	c	q	x		err_quit
	communication mode	c	c			com_mode

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Oscilloscope	channel	o	k	x+		osz_ch
	frequency divider	o	f	x+		osz_ft
	trigger value	o	t	x+		osz_tr
	trigger channel	o	c	x+		osz_tch
	storage mode	o	m	x+		osz_m
	offset	o	o	x+		
	oscilloscope on / off	o	e	x+		osz_offs
	read data (only the channel osz_ch)	o	r			osz_on
	read data (all channels)	o	s			
x+ also parametrizable, if the module is switched on (mod_on=1)						

Tab. 10: Complete table of the command codes

6.2.3 ASCII-long / ASCII-short

On the part of the module answer, two protocol variants are possible: "long" and "short" ASCII protocol. ASCII-long is particularly suited for the manual entry of instructions, e.g. by using a terminal program such as "HyperTerminal" from Windows. When this protocol is set, the module sends any information and (error) messages in clear text and sees to a distinct representation in the terminal program by means of the transfer of CR and NL control characters at corresponding points.

On the other hand, the protocol ASCII-short should be used when the instruction is to be handed over from another software such as, for example, from the software "ModuleConfigSuite" of Flexiva. If this protocol is set, any information and (error) messages in clear text are suppressed. In case of an error, only error codes are transferred.

	ASCII-long	**ASCII-short**
without error	- command code + CR + NL - sign + readout value + CR + NL - „OK" + CR + NL + NL	- command code + CR - sign + readout value + CR
with error	- command code + CR + NL - error code + CR + NL - error text + CR + NL + NL	- command code + CR - error code + CR

Tab. 11: Module answer for the reading of a parameter / value

	ASCII-long	**ASCII-short**
without error	- command code + sign + new value + CR + NL - sign + read back value + CR + NL - „OK" + CR + NL + NL	- command code + sign + new value + CR - sign + read back value + CR
with error	- command code + sign + new value + CR + NL - error code + CR + NL - error text + CR + NL + NL	- command code + sign + new value + CR - error code + CR

Tab. 12: Module answer for the writing of a parameter / value

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6.2.4 ASCII-short with checksum

Starting with firmware 2.06 a communication protocol with checksum is available. This is based on the existing protocol "ASCII-short". However, a 1-byte checksum is used now instead of resending each character received for error checking. This checksum is transmitted in each case as the last character before the CR (dec. 13) in both directions of communication.

The checksum is calculated as the sum of all transmitted bytes modulo 256. If the result is randomly 13, it is replaced by 14 in order to avoid collisions with the CR (dec. 13) as an input terminator.

	ASCII-short with checksum
without error	- command code + Σ + CR - sign + read back value + Σ + CR
with error	- command code + Σ + CR - error code + Σ + CR

Tab. 13: Module answer during reading of a parameter / value

	ASCII-short with checksum
without error	- command code + sign + new value + Σ + CR - sign + read back value + Σ + CR
with error	- command + sign + new value + Σ + CR - error code + Σ + CR

Tab. 14: Module answer during writing of a parameter / value

When reading the data from the oscilloscope no checksum is transmitted. Here, the data transmission is as in the ASCII-short protocol.

6.2.5 Switching between the protocols

The changeover between the protocol variants is executed by putting a command character in front of the respective first sequence of commands. This command character can also be sent separately. The respective protocol setting is preserved until the next protocol changeover and/or to the next restart (supply voltage gone) or reset of the module. As a standard setting, ASCII-short is set.

Protocol-option	Control character to the module
ASCII-short	$
ASCII-long	%
ASCII-short with checksum	&

Tab. 15: Protocol changeover

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6.2.6 Concrete example

To explain the above-mentioned paragraphs, the sequences of instructions to be transferred to the module and the corresponding answers of the module are listed in the following at a concrete example. The case without errors is treated.
The module variable zk_umin_g is to be read-out and a new value is to be stored in it. The corresponding code is "zn", the old value in the variable is "+3500" and the new value is "+3600". This results for the two ASCII modes in the following communication with the module:

6.2.6.1 ASCII-long

To the Module																							
ASCII	%	z	n	CR																			
HEX	25	7A	6E	OD																			
From the Module																							
ASCII		z	n	CR	NL	+	3	5	0	0	CR	NL	O	K	CR	NL	NL						
HEX		7A	6E	0D	0A	2B	33	35	30	30	0D	0A	4F	4B	0D	0A	0A						

Tab. 16: Reading ASCII-long

To the Module																							
ASCII	%	z	n	+	3	6	0	0	CR														
HEX	25	7A	6E	2B	33	36	30	30	0D														
From the Module																							
ASCII		z	n	+	3	6	0	0	CR	NL	+	3	6	0	0	CR	NL	O	K	CR	NL	NL	
HEX		7A	6E	2B	33	36	30	30	0D	0A	2B	33	36	30	30	0D	0A	4F	4B	0D	0A	0A	

Tab. 17: Writing ASCII-long

6.2.6.2 ASCII-short

To the Module																							
ASCII	$	z	n	CR																			
HEX	24	7A	6E	OD																			
From the Module																							
ASCII		z	n	CR	+	3	5	0	0	CR													
HEX		7A	6E	0D	2B	33	35	30	30	0D													

Tab. 18: Reading ASCII-short

To the Module																							
ASCII	$	z	n	+	3	6	0	0	CR														
HEX	24	7A	6E	2B	33	36	30	30	0D														
From the Module																							
ASCII		z	n	+	3	6	0	0	CR	+	3	6	0	0	CR								
HEX		7A	6E	2B	33	36	30	30	0D	2B	33	36	30	30	0D								

Tab. 19: Writing ASCII-short

6.2.6.3 ASCII-short with checksum

To the Module																							
ASCII	&	z	n	Σ	CR																		
HEX	26	7A	6E	E8	0D																		
From the module																							
ASCII						+	3	5	0	0	Σ	CR											
HEX						2B	33	35	30	30	F3	0D											

Tab. 20: Reading ASCII-short with checksum

To the Module																							
ASCII	&	z	n	+	3	6	0	0	Σ	CR													
HEX	26	7A	6E	2B	33	36	30	30	DC	0D													
From the Module																							
ASCII											+	3	6	0	0	Σ	CR						
HEX											2B	33	36	30	30	F4	0D						

Tab. 21: Writing ASCII-short with checksum

For computing the checksum the gray values are added. The residue left in the Division by 256 is the checksum. If this value is 13, it is replaced with 14.

```
char checksum;
...
checksum = 0;
   for (i = 0; i < idx; i++) checksum = checksum + buf[i];
   if (checksum == 13) checksum = 14;
...
```

Tab. 22: Example for computing the checksum in C

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6.2.7 Error messages during the communication

All sequences arriving in the module are immediately checked and processed. The following errors can occur during the reading / writing and these errors concern exclusively the parameterizing process and are not to be confused with the errors that may arise during the operation of the module and are coded in the status variable mod_state (Tab. 4):

Error code	Meaning in clear text
E0	Reserve
E1	Reserve
E2	Unknown module command
E3	Value beyond the range of values
E4	Value is only readable
E5	Device must be switched-off
E6	Elpotis could not be written. Jumper 1 must be closed.
E7	Mode of operation must be <16
E8	Min value must be smaller than max value
E9	Checksum error

Tab. 23: Error messages

6.3 Communication by Means of Terminal Software

Because of the utilization of an ASCII protocol for the communication interface, a communication with the module is possible by means if any terminal software you like. As an example, HyperTerminal is mentioned here that exists in Windows as a standard outfit (see Fig. 6). Of course, every other software can be also applied (Freeware, self-developed software) by means of which a bidirectional serial communication is possible. For the utilization of a terminal software, the protocol setting ASCII-long is recommended.

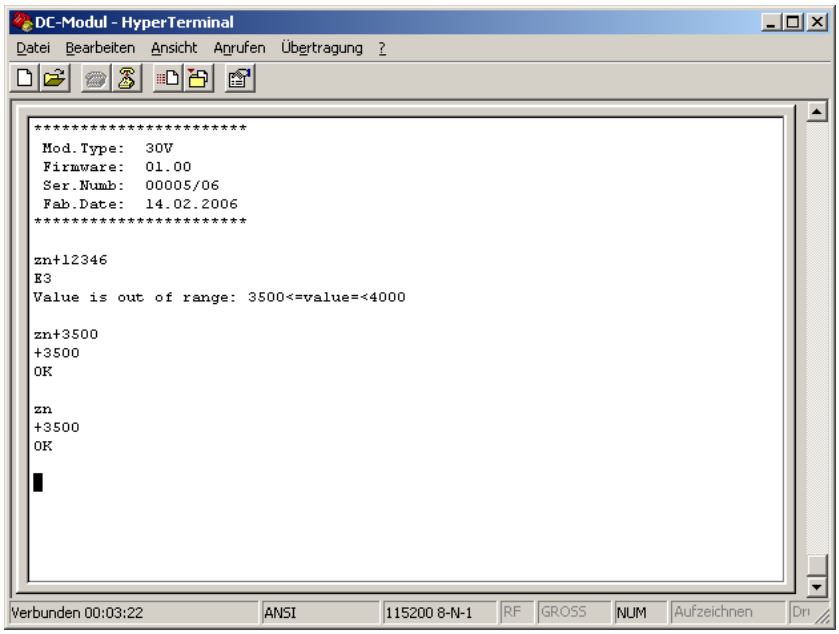

Fig. 6: Module parameterization by means of terminal software

6.4 Communication by Means of ModuleConfigSuite

Another and much more convenient possibility is the utilization of the Windows software "ModuleConfigSuite“ from the company Flexiva that is contained in the scope of delivery of the DC/DC module as a standard component. This software permits a convenient communication and a closed access (parameterizing / monitoring / storing) to all variables (parameters / commands / measured values) of every single module. Furthermore, it is possible to communicate simultaneously with up to 4 modules. The ModuleConfigSuite uses the protocol setting ASCII-short.

7 The Parameterizing Software "ModuleConfigSuite"

7.1 Preliminary Remarks

A Windows software for the PC is supplied along with the module. It is intended for the convenient parameterization and visualization of all parameters / commands / measured values as well as for the recording of select data on the fixed disk. In the following, details concerning the function and operation of this software are explained.

System Prerequisites

Hardware:
- customary PC of medium performance and RS232 interface

Operating system:
- MS Windows (from Windows XP SP2 onwards)

7.2 Installation

The software is installed like any other conventional Windows software:

1. Insert the data carrier.
2. Start the installation by means of starting the file **setup.exe**.
3. Follow the instructions given by the installation program (path entry etc.).
   a. Installation step backwards by means of a click onto **Back**
   b. Installation step forwards by means of a click onto **Next**
   c. Stop the installation by means of a click onto **Cancel**.
4. Terminate the installation by means of a click onto **Finish**.

7.3 Deinstallation

If the software is to be removed from the fixed disk, you proceed as follows:

1. Open the **Start menu** of Windows.
2. Select **System control**.
3. In the system control panel click onto the symbol **Software**.
   A list of the available programs is displayed.
4. Select from the list the symbol for **ModuleConfigSuite**.
5. Click onto **Remove**. The software is de-installed now.

7.4 Software description

7.4.1 Overview

After the start of the software and the successful establishing of a connection to one or several modules (click onto "Connect!" in the menu line), the following window is displayed in which a division into three parts that is into a menu line, a button bar directly under the menu line and the remaining display area can be recognized. Only those modules are displayed with which a connection is to be established (see paragraph "Selection and Assignment of the Interfaces“) and a connection was successfully established.

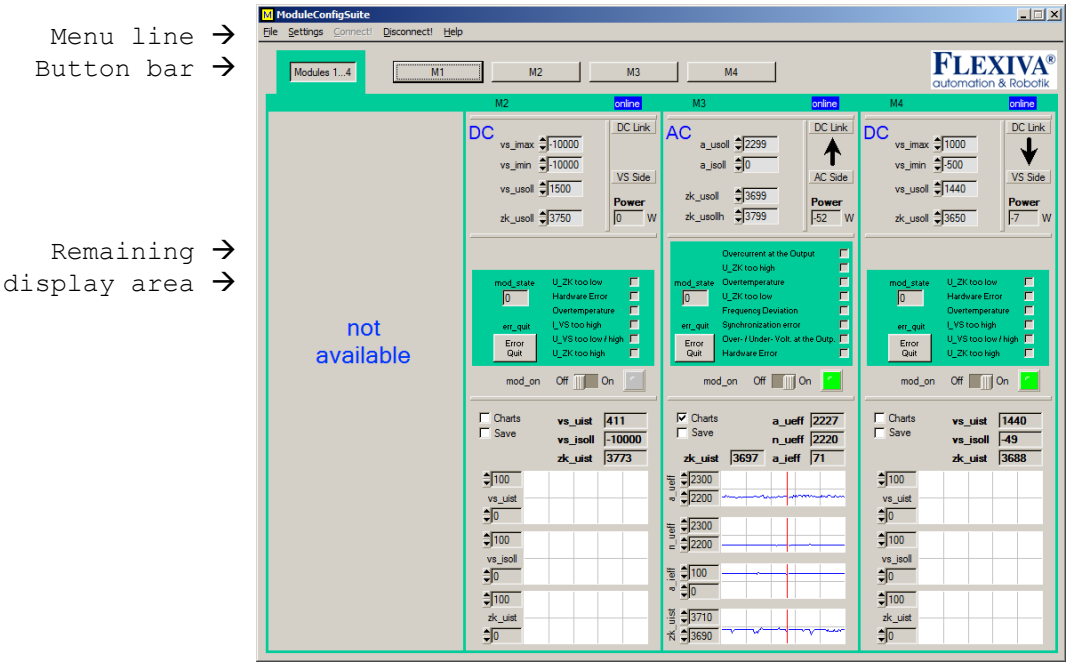

Fig. 7: Basic structure of the software

7.4.2 Single-Mode / Multi-Mode

On principle, the software distinguishes between two modes, the so-called "Single"-mode for the communication with only one single module and the so-called "Multi"-mode for the simultaneous communication with up to 4 modules. In the Single-mode, the access to all parameters of the respective module is possible while in the Multi-mode, the access only to selected parameters of the respective module is possible. In the Single-mode, the digital nameplate and temperature values of the respective module are read-out and visualized additionally. Furthermore, an oscilloscope function and a selection aid for the fixing of the mode of operation (mod_opmode) are available. The changeover between the modes is executed by means of the buttons in the upper window area. After the start of the software, the Multi-mode is automatically set.

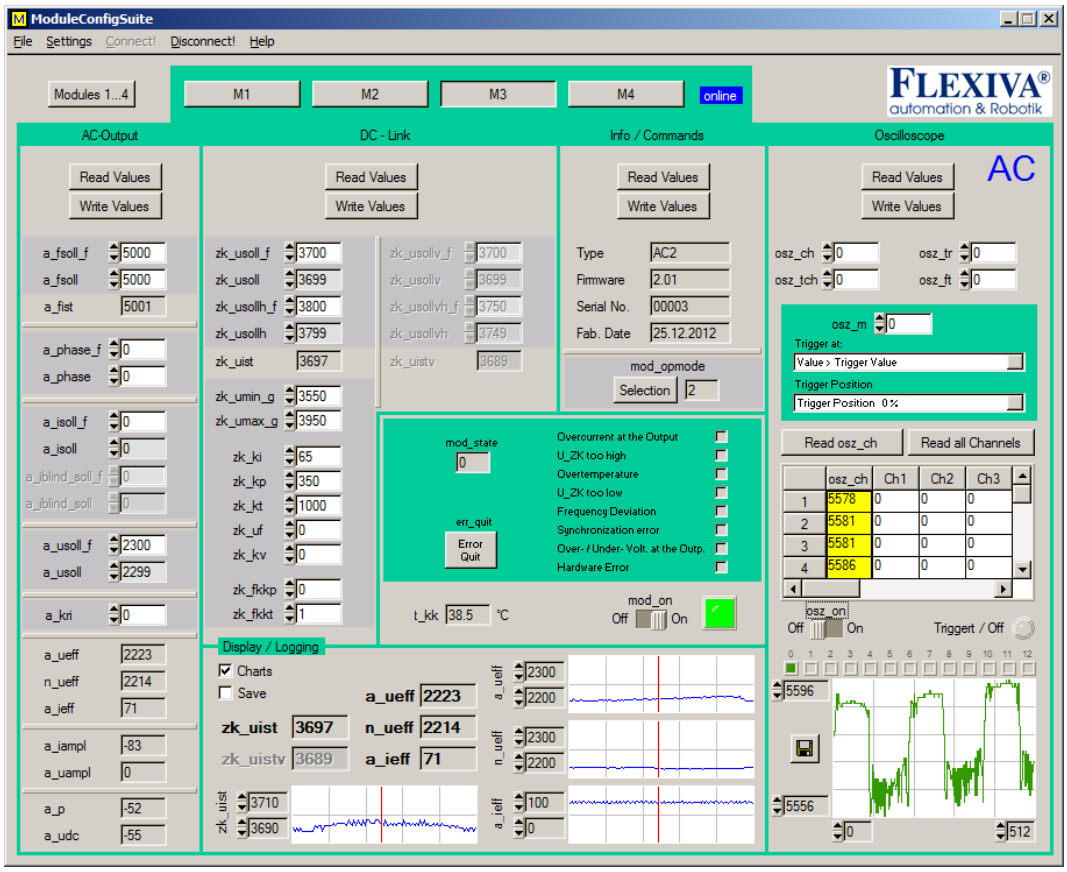

Fig. 8: Single-Mode / Module 3

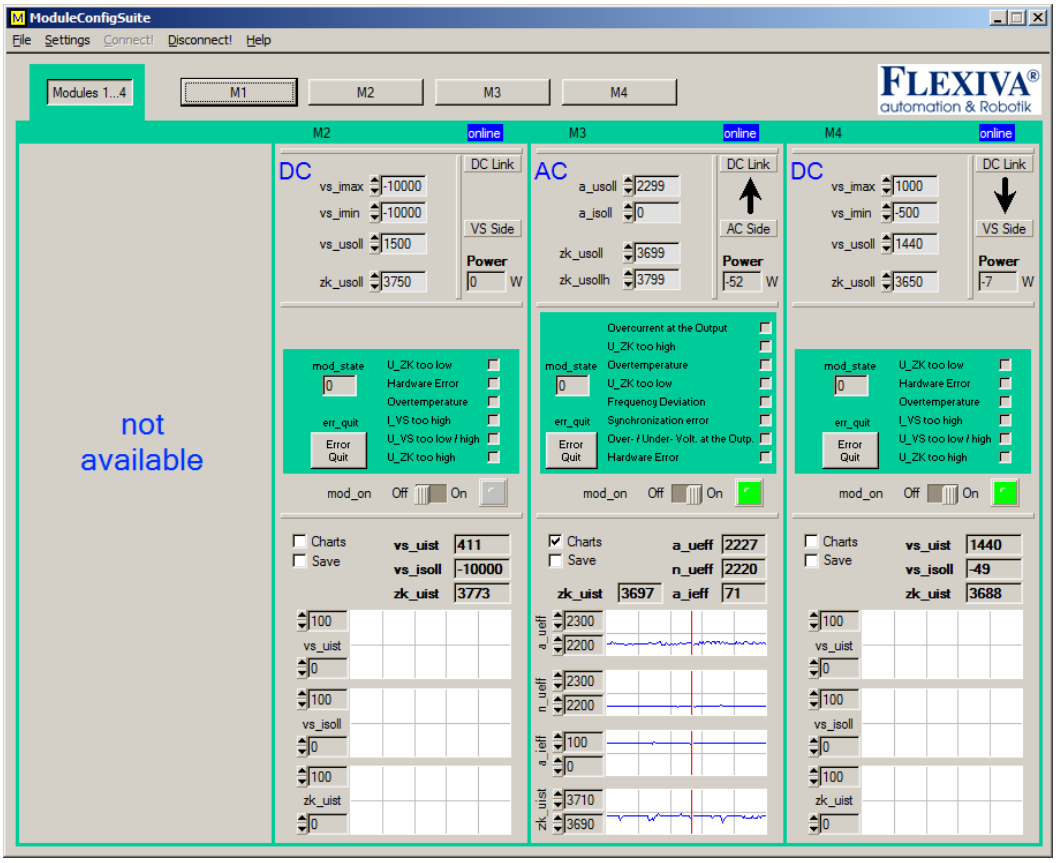

Fig. 9: Multi-Mode

7.4.3 Groupings by Means of Colors / Backgrounds

Owing to the great number of information to be represented at the same time and the diversity of the entries to be processed, the application of different colors for the logical grouping turned out to be advantageous. The legend with the explanation of the colors can be called after the selection of the menu item "Help → Color Codes".

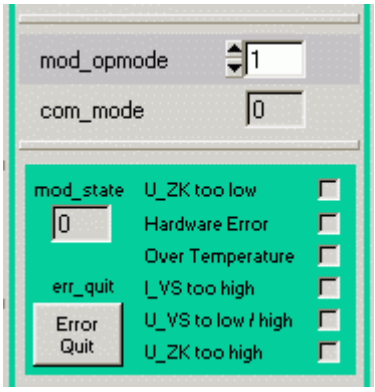

Fig. 10: Example for groupings

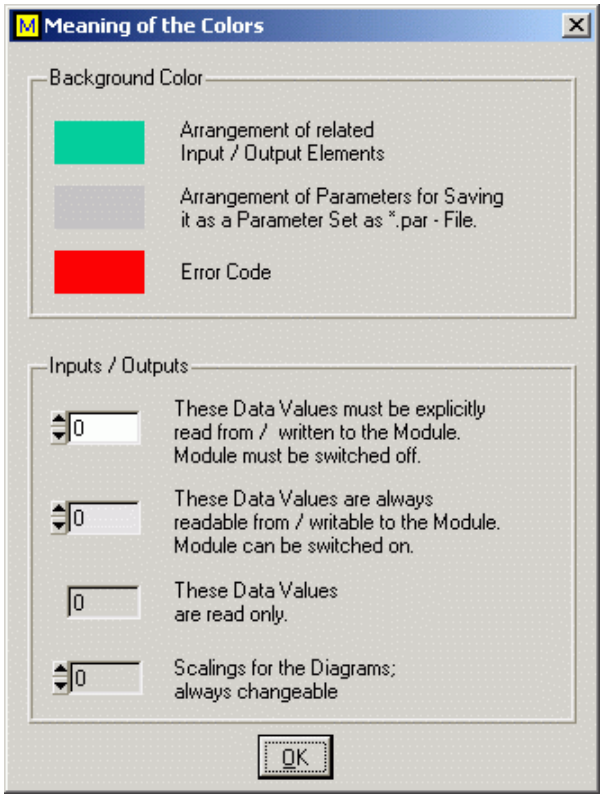

Fig. 11: Color legend

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7.4.4 Meaning of the Error Codes

All data that are transferred (for example, by a click onto one of the buttons "Write Values" in the single-mode) to the module are immediately checked there with regard to their validity. In case of an error, the corresponding error code is entered in a red field directly next to the respective display / entry element. A table with the meaning of the error codes can be retrieved by selection of the menu item „Help → Error Codes“.

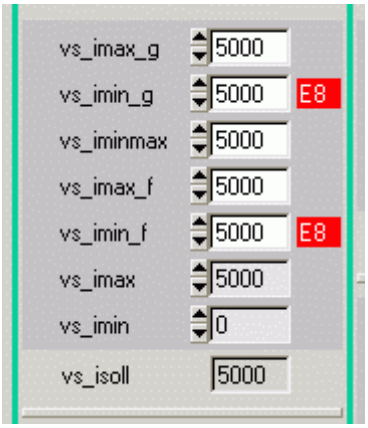

Fig. 12: Example of error codes

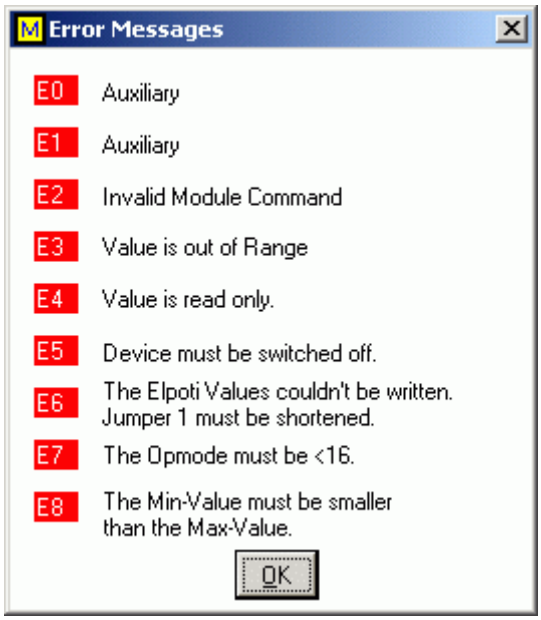

Fig. 13: Meaning of the error codes

7.4.5 Selection and Assignment of the Interfaces

The selection of the interfaces and their assignment to the modules is carried out by the selection of the menu item "Settings → Connection". Depending on the type of the module carrier, there are various possibilities available. In case of the module carrier of the type 1, the communication is executed by means of 4 separate RS232 interfaces (one for every module). The module carrier of the type 2 needs only one RS232 for the communication with all modules (is multiplexed in the module carrier).

In addition to the assignment of the interfaces, you also have to select explicitly by marking a checkbox in the configuration dialogue whether communication with the respective module is intended. This offers the possibility to include the individual modules in the communication or not.

During the selection and assignment of the rs232 interfaces, tests are carried through concerning the existence in the PC and/or availability.

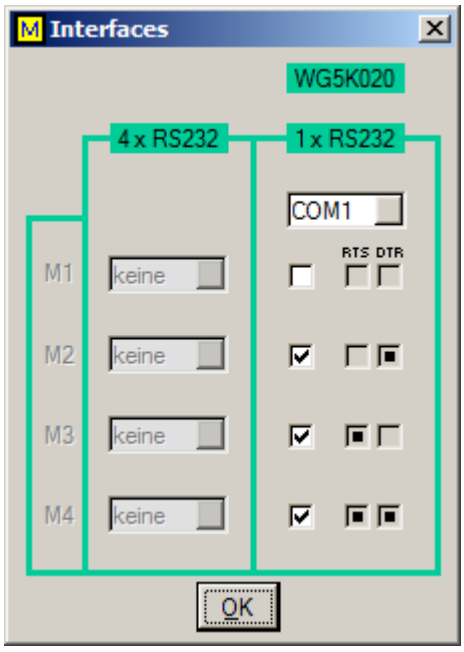

Fig. 14: Assignment of the interface

Attention: Only a test of the chosen interfaces and their assignment to the modules is made. The data connection to the modules is only established after the selection of the menu item "Connect!".

7.4.6 Connecting / Disconnecting

By the selection of the menu item "Connect!", it is possible to establish a data connection to the corresponding module (single-mode) and/or to the modules multi-mode). In the single-mode, all data are read-out once completely from the chosen module after the successful establishing of the connection and entered into the respective fields of the screen mask. In the multi-mode, only the relevant data are read-out after the successful establishing of the connection and entered into the respective fields of the screen mask. A selection of the menu item "Disconnect!" cut(s) of the connection(s).

Fig. 15: Information in case of the cutting-off of the connection

The connection is permanently monitored both during the establishing of the connection and during the existing connection. If the establishing of the connection fails and/or the connection is cut-off a corresponding hint appears.

7.4.7 Storing / Loading of Parameter Sets

In the single-mode, it is possible to store parameter sets on the PC and/or to load parameter sets that are stored on the PC. After the calling of the menu items "File → Load Parameter Set" and/or "File → Save Parameter Set", the corresponding dialogues are called for the loading and storing of files. The parameter files have got a special format that can only be read and write by the ModuleConfigSuite.

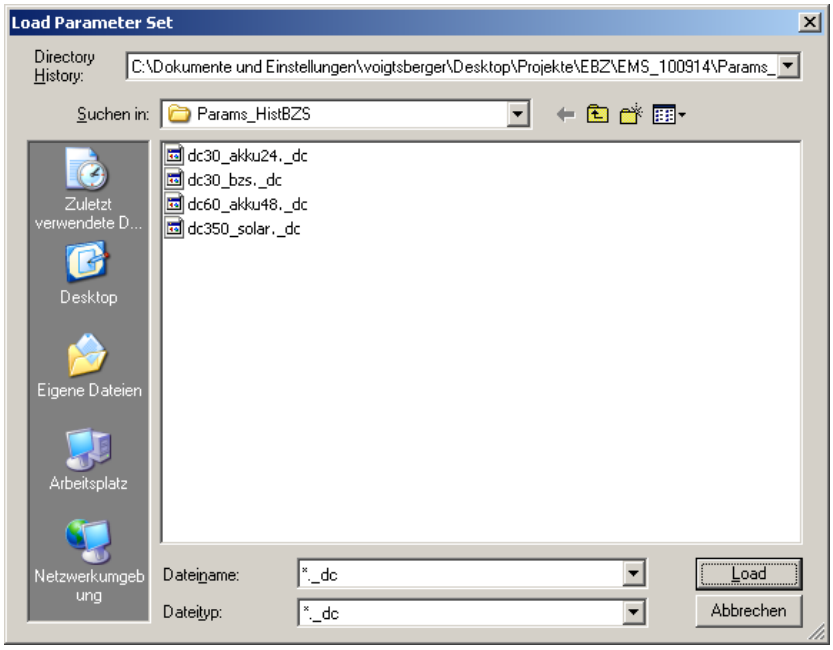

Fig. 16: Dialogue for the loading of parameter files

When such a file is loaded from the PC, all parameters are immediately entered into the corresponding fields. In the reverse case, only the corresponding fields are read-out for the storing of the parameters in such a file. Only such fields with the respective colored background are taken into account.

7.4.8 Reading-Out / Parameterization

All relevant data are automatically read-out from the module and/or the modules during the changeover between the two main modes single-mode and multi-mode (buttons: "Modules 1…4" and "M1" … "M4") or during the establishing of the connection ("Connect!"). In the single-mode, all data are read-out from the selected module and entered into the corresponding fields of the screen mask, in the multi-mode only the relevant ones. The requirement is in both modes an existing data

connection to the respective module and/or to the respective modules.
In addition to that, it is possible in the single-mode to explicitly initiate the reading-out of the data from the module and/or the storing of data in the module by means of a click onto one of the buttons "Read Values" or "Write Values". Only the data of the respective column (e.g. "DC link") are taken into account during this.

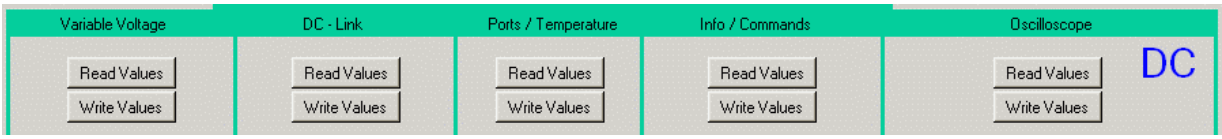

Fig. 17: Buttons for the reading-out / parameterization in the single-mode

Both in the single-mode and in the multi-mode, some data are immediately transferred after their entry / modification (see colour codes). These are in particular the parameters: vs_imax, vs_imin, vs_usoll and zk_usoll.

7.4.9 Data Visualization / Recording

In the single-mode as well as in the multi-mode, in case of an existing connection, the parameters zk_uist, vs_iist and vs_uist are permanently read-out and visualized with a transfer rate of approx 10 Hz when the connection exists. If the check boxes "Charts" and "Save" are marked, in addition to that, the three parameters zk_uist, vs_iist and vs_uist are simultaneously visualized in diagrams and data are stored (data-logging) in the ASCII format.

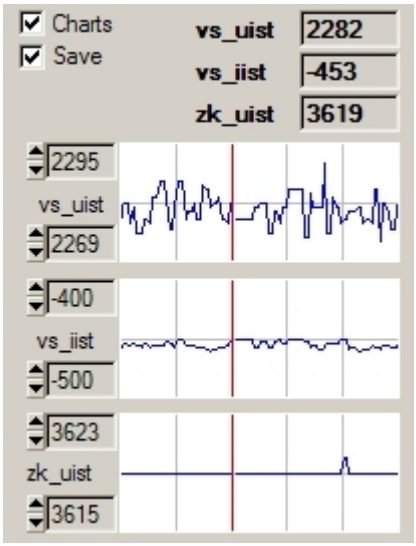

Fig. 18: Dialogue field storing / visualizing

zk_uist	vs_isoll	vs_uist
3640	-326	1585
3640	-326	1586
3641	-327	1587
3641	-325	1584
3640	-327	1589
3640	-325	1584
3640	-327	1587
3640	-327	1585
3641	-326	1582
3640	-325	1581
3641	-324	1583
3640	-328	1585
3640	-327	1586
3640	-327	1586
3641	-328	1584
3641	-326	1587
3641	-327	1585
3640	-327	1587
3640	-326	1583
3640	-327	1587
3640	-328	1585
3640	-327	1582

Fig. 19: Recorded ASCII data

During every new establishing of a connection by means of a click onto "Connect!") and a marked "Save", a new data file (a separate one for every module) in the ASCII format with the file extension *.asc is automatically generated in the working directory of the ModuleConfigSuite. For this purpose, it does not matter whether you are in the single-mode or in the multi-mode. The file names of the generated files are composed of the module code as well as date and time of the beginning of the recording. Consequently, the file name “M3_110406_114231.asc“ designates a data recording of the module 3 that started on 11th April 2006 at 11:42:31 a.m.
For safety reasons, the data are stored only in the corresponding mode (single-/ multi-) respectively in the single-mode only for the module just selected. If, for example, the storing is marked for all 4 modules in the multi-mode, only a storing of the data in the file of the corresponding chosen module is carried out in the single-mode and no (background) storing of the data of all 4 modules is executed. Single-mode and multi-mode store to the same data file of the respective module.

7.4.10 Selecting of the Mode of Operation

In the Single-mode, it is possible to select the required mode of operation in a simple way. By means of simple dialogue field (invocation by means of button "selection" in the field "mod_opmode“), all bits of the parameter mod_opmode and their dependencies from each other are visualized and the corresponding decimal value of the parameter mod_opmode is calculated. After clicking "Apply", this value is applied and stored in the module.

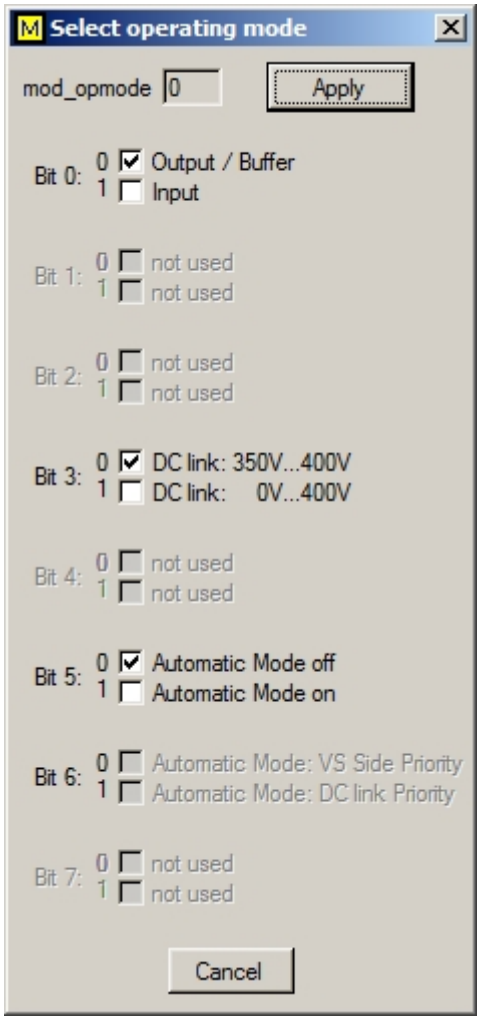

Fig. 20: Dialogue for the selection of the mode of operation

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8 Maintenance service and repairs by the customer service

According to the general terms and conditions of sale and delivery, WARRANTY is furnished for the device provided by the manufacturer. If malfunctions or damages occur at the device during the warranty period warranty is given for according to the terms and conditions of warranty, the manufacturer shall execute the repair or the replacement of defective components after a prior examination.

The manufacturer shall be responsible for the device in its original configuration.

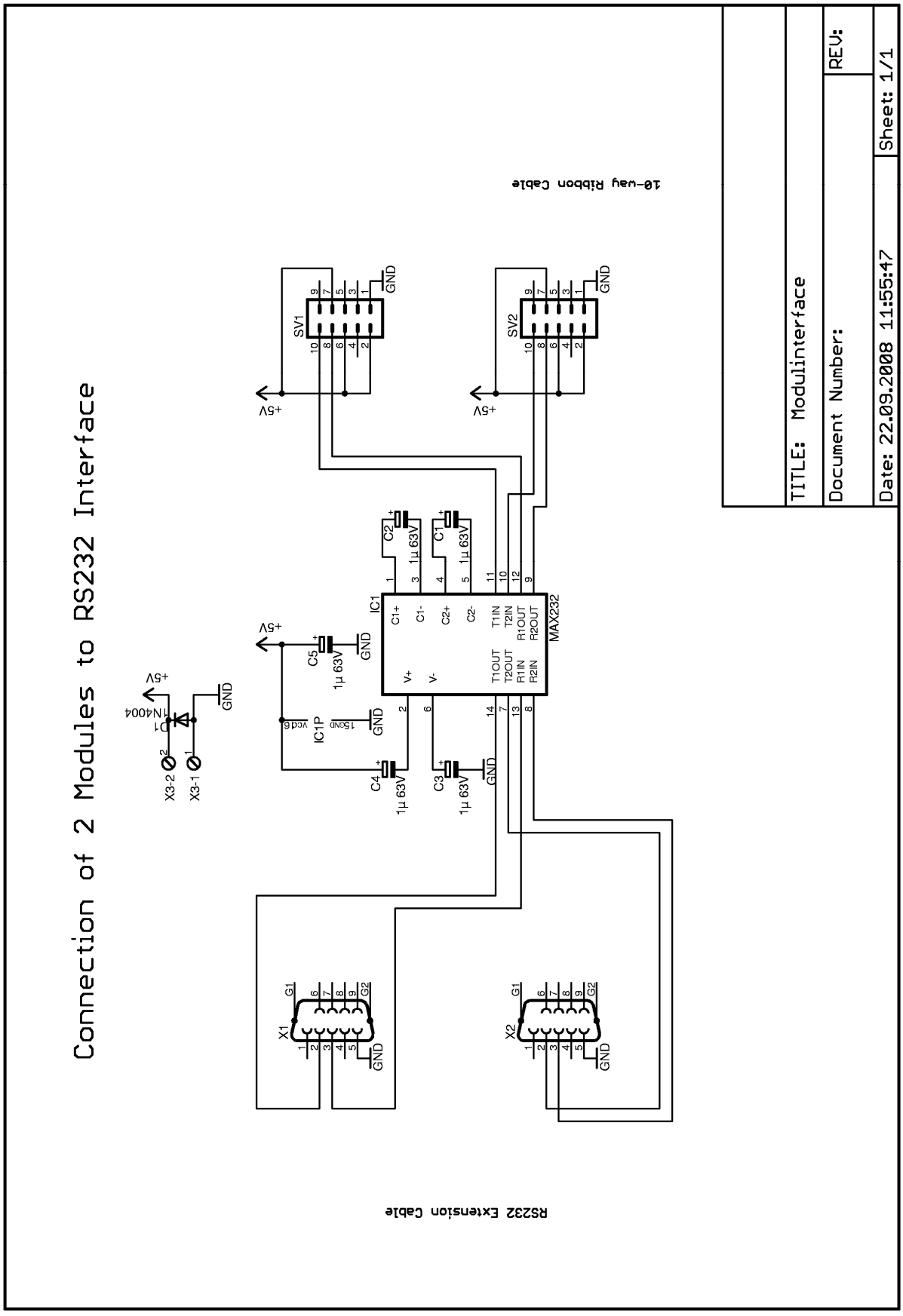
Only the manufacturer shall be authorized to carry out all and any interventions that concern the device, the structure, the software, or the operating cycle of the device or these interventions exclusively require the express prior consent of the manufacturer.

Attention

The environmental conditions agreed in the contract must be met.

The manufacturer shall not be liable for any damages owing to the improper or false utilization of the device as well owing to damages arising from interventions to the device that are not expressly required in the present manual.

9 Appendix


Connection of 2 Modules to RS232 Interface
10-way Ribbon Cable
RS232 Extension Cable
SV1
SV2
X1
X2
X3-1
X3-2
D1
1N4004
IC1
MAX232
IC1P
C1
C2
C3
C4
C5
1µ 63V
+5V
GND
TITLE: Modulinterface
Document Number:
REV:
Date: 22.09.2008 11:55:47
Sheet: 1/1

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